Benthic Macroinvertebrate and Water Temperature Monitoring for Clark County Watershed Assessments in 2004

Clark County Public Works
Water Resources Program

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Prepared by
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Introduction

This document summarizes water quality monitoring conducted by the Clark County Water Resources Program. It is intended to support the watershed assessment effort in Clark County led by the Lower Columbia Fish Recovery Board (LCFRB) in support of salmon recovery (LCFRB, 2004). The work components making up this watershed assessment were complex. Assessments operated at many scales, including the watershed, subwatershed, and habitat-reach scales, and on differing timelines among several project partners and consultants. The component of water temperature monitoring and benthic macroinvertebrate sampling targeted reach scale assessments of water quality and were intended to support habitat data collected at a similar scale. Monitoring for hydrology, physical habitat, water temperature, and benthic macroinvertebrates occurred through the coordinated efforts of Clark County Water Resources and the Lower Columbia Fish Recovery Board. Separate Quality Assurance Project Plans were written for the components of:

- hydrologic monitoring (Hutton, 2003),
- benthic macroinvertebrate and temperature monitoring (Wierenga, 2004), and
- physical habitat description (no QAPP required; monitoring plan developed by the LCFRB and summarized in Chapter 1 of the reference below).

Results of the watershed assessment and habitat surveys are summarized in separate documents that are available from the Lower Columbia Fish Recovery board's website at (http://www.lcfrb.gen.wa.us/document_library.htm):

- Lower Columbia Fish Recovery Board, Dec. 2004. Kalama, Washougal and Lewis River Habitat Assessments: Chapters 1-6.
- Lower Columbia Fish Recovery Board, Dec. 2004. Lower Columbia Salmon Recovery and Fish and Wildlife Sub-basin Plan.

Problem Statement

Numerous studies (Wade 2001; Wade 2000; Wildrick et al. 1998; Hutton 1995) have identified major environmental data gaps that limit the ability to understand overall watershed processes and to identify and prioritize specific management actions for salmon recovery in Clark County. The LCFRB's Interim Habitat Strategy (LCFRB, 2004) provided a tool to prioritize subwatersheds and major stream segments for further data gathering.

Few watersheds in the lower Columbia River region have adequate baseline data available to identify and prioritize restoration projects or make judgments about how effective habitat restoration efforts have been. Baseline data collection is critical to documenting the trajectory of habitat conditions and fish population status in each watershed. Habitat and water quality monitoring projects provide baseline data from which watershed program progress and the need for changes of strategy or priorities can be made.

In most cases, there is no information to describe temperature conditions to characterize subwatershed suitability for salmon habitat. Additionally, benthic macroinvertebrate data, which can provide a strong indication of overall biological integrity and the level of human disturbance for a stream, is lacking.

While general descriptions of stream habitat conditions based on GIS data and miscellaneous observations may exist at subwatershed summary scale, little information based on systematic gathering of field data is available at the habitat reach scale. A separate component of this

watershed assessment project records habitat conditions using US Forest Service protocols to describe conditions in accessible parts of the priority reaches (LCFRB, 2004).

Project Description

Overall Watershed Assessment Goals

This water quality monitoring project addresses part of the overall goal of the LCFRB watershed assessments, "To understand and describe the habitat conditions in the watershed necessary to maintain viable populations of anadromous salmonids."

This monitoring effort also addresses the goal of Clark County's Clean Water Program, "To protect water quality in Clark County through stormwater management." The requirements in Clark County's NPDES municipal stormwater permit addressed by this project include:

- Develop and implement receiving water characterization, watershed characterization, and basin management effectiveness monitoring;
- Evaluate the overall program effectiveness by providing baseline data in developing areas where streams are influenced by storm water runoff;

The results of this project inform Clark County, the LCFRB, the general public, the Washington Departments of Ecology and Fish and Wildlife, and US Environmental Protection Agency about watershed conditions, fish habitat, and biological potential within the areas of study.

Benthic-macroinvertebrate and Water Temperature Monitoring Goals

The primary goal of this project was to describe benthic macroinvertebrate communities and to identify water temperature limitations to salmonid production at priority salmon recovery reaches in Clark County. The benthic macroinvertebrate and water temperature data augments physical habitat surveys performed by the project partners, including the LCFRB and consultants. Results also provide information to characterize conditions as a baseline for future reference and for comparison to other subwatershed characteristics under further analysis of receiving water conditions and stormwater program effectiveness.

In most cases, project budget allowed for only one sample per subwatershed. In such cases an effort was made to sample a habitat reach in the lower part of the subwatershed to provide an indicator of probable overall upstream conditions as they contribute to water quality, hydrology and sediment flux in the reach sampled. Sampling one site per subwatershed places limitations on the results because while benthic macroinvertebrate communities are an excellent indicator of stream biological condition, the results at an individual site are influenced by both upstream watershed conditions and habitat conditions nearer the sample location.

Methods

Design

Monitoring Station Selection

Sample sites for benthic macroinvertebrate and water temperature monitoring were selected from a list of priority salmon recovery reaches provided by the LCFRB and consultants. The priority reaches focused on four watersheds within or partially within Clark County, including the North and East Fork Lewis Rivers, Salmon Creek, and Washougal River (Figure 1). The selection of priority reaches for habitat surveys followed a methodology described in the habitat survey reports (LCFRB, 2004). In summary, crews were attempting to survey reaches at least a half-mile in length, from targeted proportions of EDT model reach Tiers 1 through 4. Although field work for the water quality sampling coincided with field work for the habitat assessments, crews were typically not surveying the same locations at the same time. Securing access to adequate lengths

of priority reaches proved challenging and influenced final reach selection. Reaches were occasionally selected only a few days before field work took place. In most cases habitat and water quality surveys took place on wadeable reaches of tributary streams or main stem reaches of smaller streams. Final station selection within a reach (for instance riffles for macroinvertebrate monitoring) followed procedures detailed in the referenced field protocols.

Monitoring Characteristics and Frequency

The primary characteristics of this project included benthic macroinvertebrate enumeration and identification and continuous water temperature recorded at hourly intervals. The project partners performed field measurements and collected biological samples at varied schedules over the sampling period. Water temperature was recorded from late spring through the summer, typically from May to October to measure the warmest period of the year. Macroinvertebrate samples were collected from late-summer to fall.

Water Quality Monitoring Data Analysis

Ten measurements, or metrics, that describe the community of benthic macroinvertebrates were calculated from the raw benthic macroinvertebrate data. The Benthic-invertebrate Index of Biological Integrity (B-IBI) is a regionally developed index, calculated from the set of metric data and used as an overall indicator of stream health (Karr, 1998; Karr and Chu, 1999). The index is used to measure changes in biological communities from activities impacting the stream or watershed, both degrading and rehabilitating actions. Researchers have found the B-IBI to be sensitive to minor impacts from human disturbance within streams in the Northwest (Cole, 2002; Fore, 1999; Merritt et al., 1999).

The continuous water temperature data was analyzed using a spreadsheet program that calculates summary statistics on continuous data files. Calculated metrics include the 7-day moving average daily maximum water temperature, maximum water temperatures observed, dates of occurrence, and duration over specific temperature criteria, e.g. the number of days over 64°F.

Field Procedures

Calibrating Field Instruments

Equipment calibration, quality assurance, and field data collection protocols for all data collected are described in the Standard Procedures for Monitoring Activities, Clark County Water Resources Section (2002). The Onset HOBO Pro water temperature dataloggers used for water temperature measurement are factory calibrated and cannot be changed. Procedures to verify the accuracy of the loggers are discussed in the 'Quality Control Procedures' section of this document.

Deploying Water Temperature Dataloggers

Detailed methods for field procedures and data analysis are available from Clark County Water Resources.

Water temperature dataloggers were deployed in May and June of 2004, prior to finalizing the list of reaches to be surveyed for habitat and benthic macroinvertebrates.

Water Resources deployed or coordinated the deployment of water temperature loggers at 18 stations on the East Fork Lewis and Washougal Rivers, and on Cedar (North Fork Lewis River) and Salmon Creeks. Table C-1 in Appendix C lists station locations, the agency or consultant collecting temperature data at each station, and the relationship between these stations and other water quality monitoring projects.

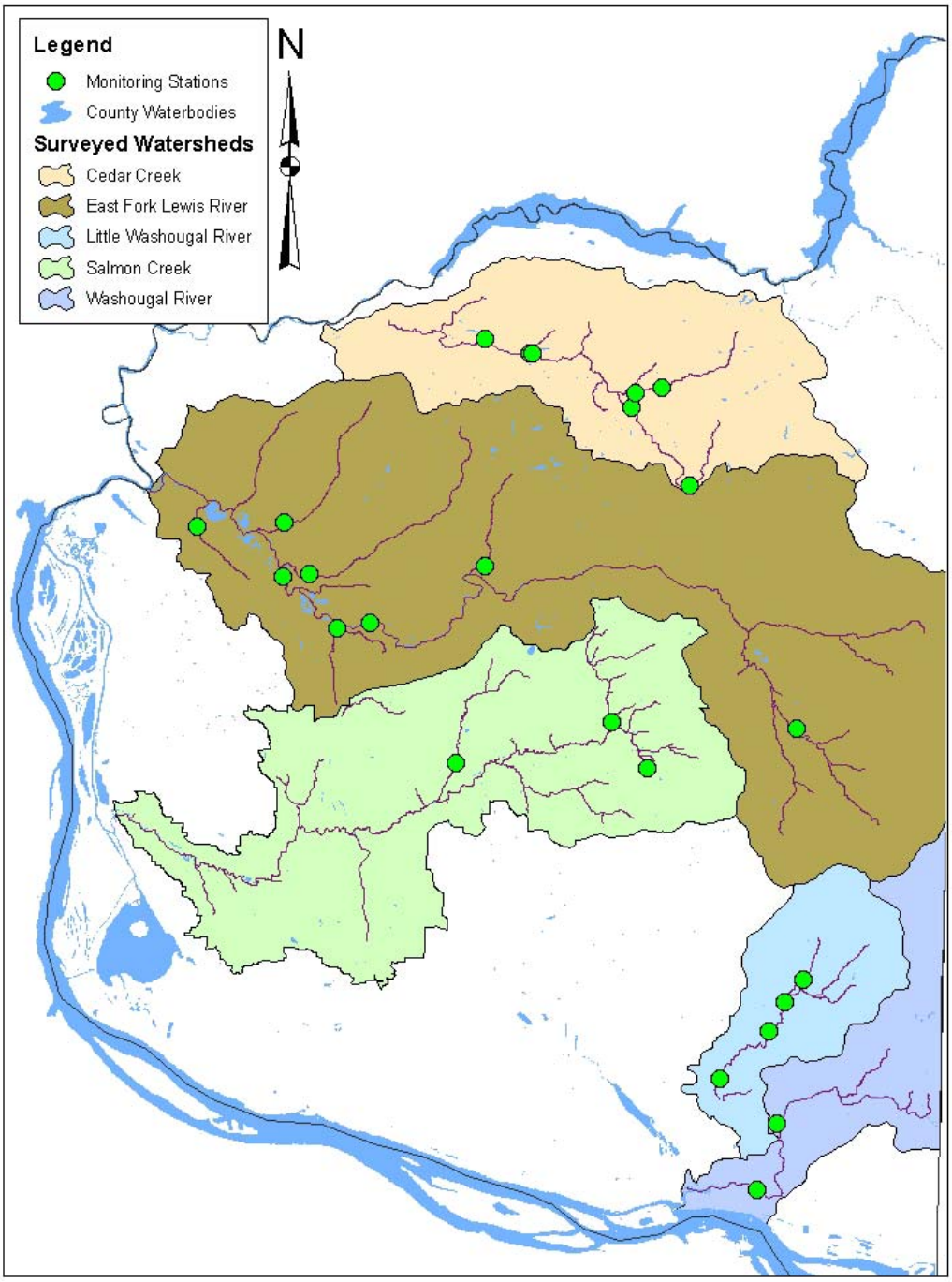

Figure 1. Map of the watersheds where habitat surveys and water quality monitoring took place; locations of benthic macroinvertebrate and continuous water temperature monitoring are indicated.

Hobo loggers were tested and installed according to procedures outlined in Standard Procedures for Monitoring Activities: Clark County Public Works Water Resources (2003), based on the Timber Fish and Wildlife Monitoring Program method manual (Schuett-Hames, et.al, 1999). Design Analysis loggers and Therm X thermisters were installed as part of permanent stream-gaging equipment using USGS methods.

Collecting Macroinvertebrate Samples

Benthic macroinvertebrate samples were collected from an approximate 500-foot length of stream within a priority reach. Individual kick-net samples from four riffles were combined to create the composite sample. A total of 8 square feet of stream substrate was disturbed and the dislodged material and macroinvertebrates were collected in a 500-um mesh d-frame kick net. Samples were stored in 1-L plastic bottles and preserved immediately with ethanol.

Laboratory Procedures

Clark County Water Resources contracted with Rhithron Associates, Inc. for all benthic-macroinvertebrate taxonomic evaluation. Lab contact information is provided below:

Wease Bollman
Rhithron Associates, Inc.
1845 South 12th West
Missoula, Montana 59801
(406)721-1977
www.rhithron.com

Benthic macroinvertebrate samples were preserved immediately after collection and shipped to Rhithron Associates, Inc. at the conclusion of the field season. Laboratory analyses were performed in accordance with Ecology-approved methods for standard taxonomic identifications and metrics (Plotnikoff and Wiseman, 2001). Macroinvertebrates were enumerated and identified to the lowest practicable level, typically to the genus species level.

Quality Control

Laboratory QC

Contracted labs perform QC for laboratory analysis of benthic macroinvertebrate samples, including sorting efficiency and identification verification, according to their quality assurance guidelines. Water Resources has requested that QC for laboratory analysis of benthic macroinvertebrate samples be performed according to Ecology-recommended procedures (Plotnikoff and Wiseman, 2001).

No other laboratory work was planned for this project.

Field QC

No formal field measurements for basic water chemistry parameters were performed in the reaches sampled for macroinvertebrates. Time and budget did not allow for duplicate riffle-composite samples for laboratory enumeration and identification.

Each HOBO Pro temperature datalogger was checked for accuracy before and after deployment with a VWR NIST traceable digital thermometer. This equipment meets stringent accuracy and resolution requirements for temperature measurements and its performance has been documented. Water baths were used giving two points to be checked that approximated a range of temperatures encountered during the deployment period.

Results

The results section of the report is intended to be concise on a reach-by-reach basis. Results of the riparian and hydromodifications analysis and the habitat surveys were reported in detail in the watershed assessment documents (LCFRB, 2004). The habitat data from the reaches where water quality data was also collected are compiled and summarized in this report, along with benthic macroinvertebrate community and water temperature metrics. The results section is organized by watershed and includes an overall summary of habitat strengths, weaknesses, and restoration opportunities as described in the habitat reports (LCFRB, 2004). Also included in the watershed summary section are a field work activity summary and a summary of the habitat, water temperature, and benthic macroinvertebrate data.

Following each watershed's general summary are individual data reports for priority reaches where both habitat and benthic macroinvertebrate surveys were completed. It is intended that the watershed summaries provide the reader with a broader view of conditions, while the reach-by-reach data reports examine, in detail, reach-specific conditions. The summaries of water quality and pertinent habitat variables serve as a catalog of conditions that, when coupled with the reach summaries in the watershed assessment reports, provide a comprehensive description of the conditions found in various Clark County streams.

Appendix C includes a summary data table (Table C-1) that provides the compiled habitat, water quality, and macroinvertebrate data by EDT reach.

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Section 1 - North Fork Lewis River Watershed Summary

Conditions and Opportunities (from Lower Columbia Fish Recovery Board, Dec. 2004. Kalama, Washougal and Lewis River Habitat Assessments: Chapter 3: The North Fork Lewis River Basin)

- *Strengths*
    - Spawning gravels were distributed throughout the entire NF Lewis basin in useable amounts.
    - Cedar Creek has potential for increased salmonid production with implementation of appropriate enhancement restoration actions.
- *Weaknesses*
    - In the NF Lewis River system, fair to poor riparian stand conditions were found in over 68% of the riparian corridor assessed and a high proportion of the stands were dominated by deciduous species rather than conifers.
    - Agricultural and rural residential development has encroached riparian habitat and has adversely impacted large wood recruitment.
    - Current riparian conditions likely result in exceedances of water temperature standards in NF Lewis River tributaries.
    - High water temperatures in Cedar Creek are associated with land use practices that have impacted riparian habitats.
    - Substrate embeddedness was high in the Cedar Creek subbasin including the Chelatchie Creek subbasin.
- *Restoration Opportunities*
    - In general, opportunities in the NF Lewis River system include protecting existing riparian vegetation and promoting recovery where possible. Efforts to preclude future encroachment into the riparian zone or reversal of prior encroachment should be considered. Specifically, riparian plantings in John Creek, and Cedar Creek reaches 2, 3, and 6 could shade the creek to keep water temperatures lower and offer future potential for large wood recruitment.
    - Large wood placement is occurring in the tributary reaches and should be encouraged at sites where the structures have a good likelihood of resisting high flows.
    - Low gradient portions of Cedar Creek reach 6 provide good opportunities for further wood placement.
    - Cedar Creek may benefit in the near future from fine sediment source control, particularly below the confluence with Chelatchie Creek in reaches Cedar 2-5. Cedar 6 upstream of the Chelatchie Creek confluence would also benefit from fine sediment source control. At current embeddedness levels, relatively small increases in fines concentrations would be expected to result in measurable decreases in intra-gravel survival of fish. Cedar Creek reach 6 should be the focus of preservation efforts to prevent further degradation from development.
    - Spawning gravel enhancement is a possibility in Cedar Creek reach 6 through implementation of in-stream structures that reduce local gradients or provide roughness with the goal of trapping and creating in-channel deposits of gravel.
    - The middle reaches of Cedar Creek may respond positively to sediment source control (e.g. livestock access and riparian re-vegetation measures), both locally and upstream in Chelatchie Creek.

Data Summary for the North Fork Lewis River Watershed

Cedar Creek was the focus of Water Resources monitoring efforts in the North Fork Lewis River watershed. Active restoration projects and community support for salmon and steelhead recovery necessitates an understanding of 1) the health of Cedar Creek and its tributaries and 2) the impact of stormwater runoff from county-owned property and how it can be managed to minimize adverse impacts.

During the 2004 field season, habitat surveys were conducted by R2 Resource Consultants, Inc. in seven EDT reaches in the NF Lewis River watershed, many of which were in the Cedar Creek watershed. Figure 1-1 below shows the location of the Cedar Creek reaches surveyed.

Utilizing the efforts of volunteers and staff from Clark Public Utilities, Water Resources coordinated the deployment of five water temperature data loggers in the Cedar Creek system, including four mainstem stations and one Chelatchie Creek station. Two stations were located in the main stem's upper reach due to its length. Also with the help of volunteers, five benthic-macroinvertebrate samples were collected from the mainstem and tributaries.

In all, water quality and habitat surveys were completed in four EDT reaches, with a partial survey completed in John Creek, lacking only water temperature data.

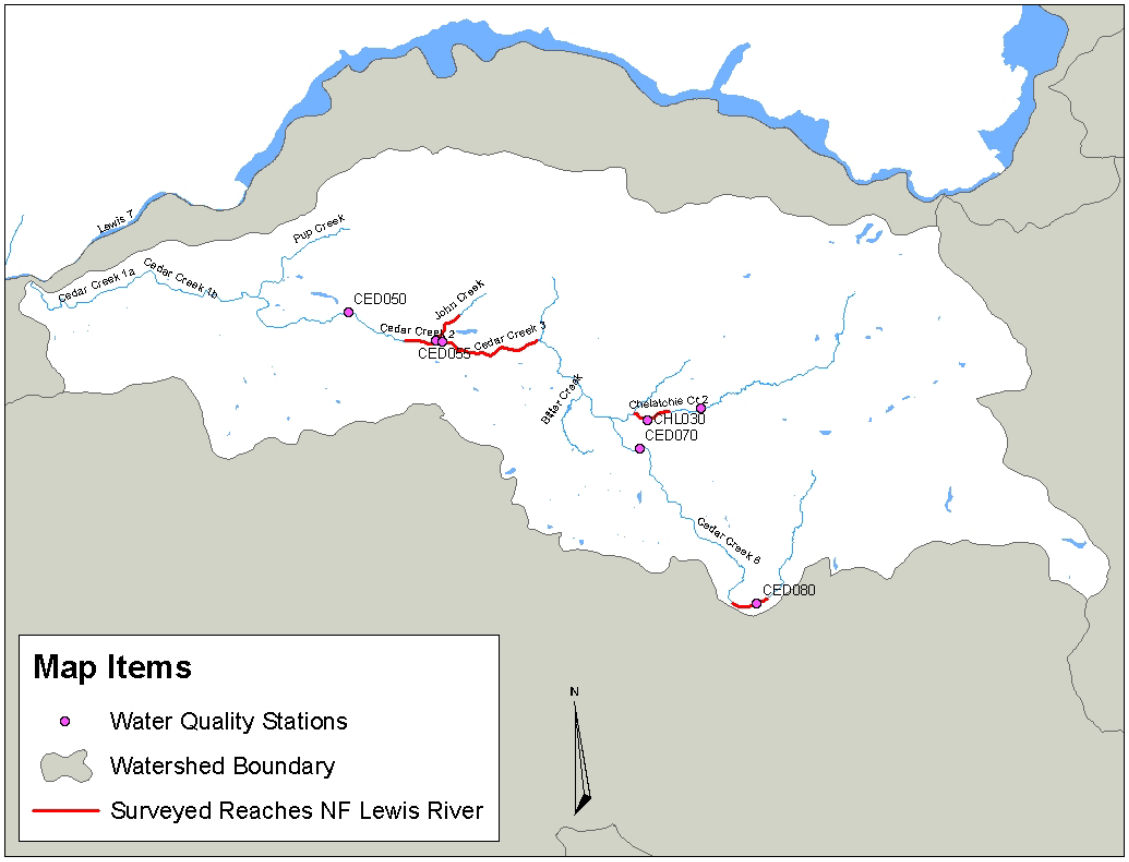

Figure 1-1. Map of the Cedar Creek watershed showing the reaches where habitat surveys were performed and locations of the water quality monitoring stations; macroinvertebrate samples were collected from the CED050, CED055, CED080, CHL030, and JON010 stations

Water Temperature Summary

Table 1-1 summarizes the continuous water temperature data for the Cedar Creek watershed stations that were monitored in 2004. The summary value is the maximum of the 7-day moving average of daily maximum temperatures. The 2003 Washington State water quality standards, currently under EPA review, utilize this metric to determine temperature compliance. The duration greater than 64 deg-F indicates the number of days on which the *daily* maximum temperature exceeded the 64° F criterion. Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent out of compliance is also of interest.

High water temperatures were observed throughout much of the lower mainstem of Cedar Creek (Table 1-1; Figure 1-2). Water temperatures were higher than the target criteria at nearly all stations, with values near the target criteria in the upper reaches of Cedar Creek above the town of Amboy, Washington. Water temperature in Chelatchie Creek met target criteria; however, a datalogger deployed at Clark County's long term monitoring station at the mouth of Chelatchie Creek gave a maximum value of about 65 deg-F in 2004. Below the Chelatchie Creek confluence water temperatures were very high, specifically through Cedar Creek reaches 2 and 3. In the several miles between Chelatchie Creek and John Creek, Cedar Creek water temperature increased to a maximum observed value of 74 deg-F in 2004. Two tributaries, Brush Creek and Bitter Creek, enter Cedar Creek in this stretch.

Elevated temperature data relates to sparse riparian vegetation and a lack of shading of the stream channel, particularly in the lower reaches of Cedar Creek and its tributaries described by the riparian assessment. In general, much of the area over the river channel was open to the sky. Higher amounts of forest cover in the upper tributaries likely result in lower water temperatures relative to the lower tributaries, although values may still be at levels that are harmful to aquatic life. Controlling channel width and providing shade to the lower mainstem Cedar Creek are critical to reducing water temperatures.

Table 1-1. Cedar Creek water temperature data summary, summer 2004; the reaches are roughly ordered from upstream to downstream. Cedar Creek 6 had two monitoring locations, with a and b representing downstream and upstream stations, respectively.

EDT Reach Name	Date	7-DAD Max Temperature	Duration > 64 deg-F
Cedar Creek 2	8/12/04	74.0	57
Cedar Creek 3	8/12/04	74.0	55
Cedar Creek 6a	7/25/04	67.1	36
Cedar Creek 6b	8/13/04	68.2	38
Chelatchie Creek 2	7/26/04	62.7	0

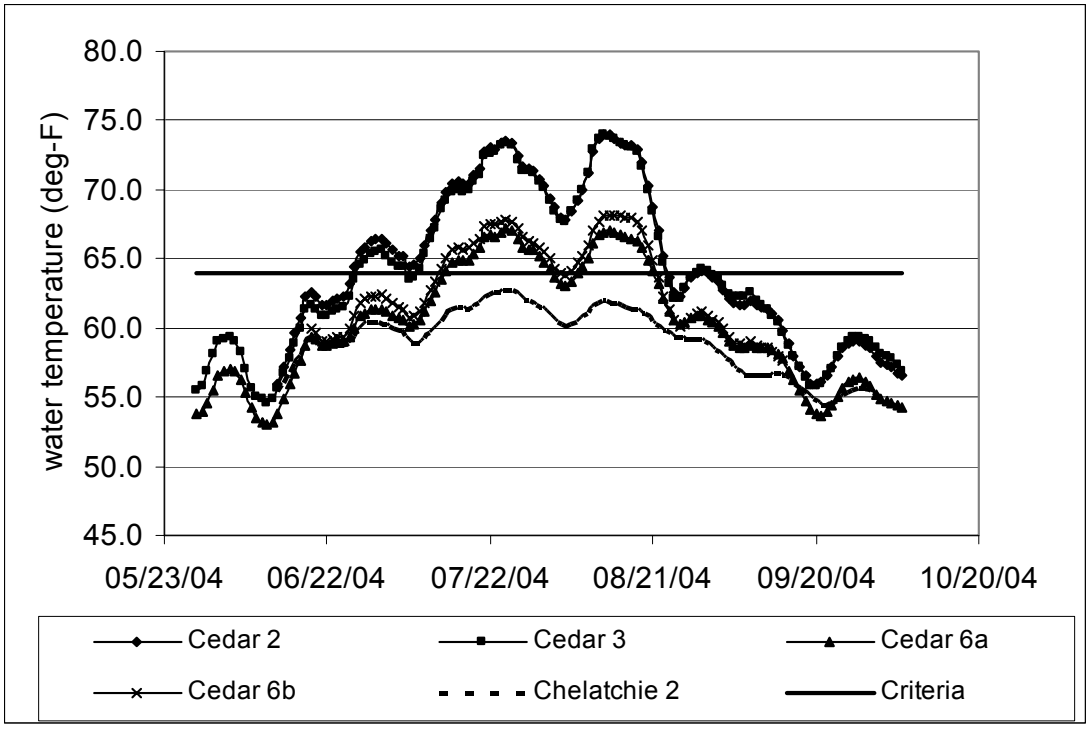

Figure 1-2. Cedar Creek and Chelatchie Creek water temperatures, as depicted by the 7-DADMax value, measured in 2004; a criterion shown is the 64-deg F target.

Biological Survey Summary

Water Resources utilizes the widely applied Benthic Macroinvertebrate Index of Biological Integrity, or B-IBI (Karr, 1998), to measure the health of streams based on the macroinvertebrate population.

Karr's B-IBI is based on ten metrics that describe various aspects of stream biology, including tolerance and intolerance to pollution, taxonomic richness, feeding ecology, reproductive strategy, and population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species are often the most sensitive to disruption and will be the first to disappear from a stream as human disturbance increases.

The raw data value for each metric are converted to a score of 1, 3, or 5, and the ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10-24 indicate low biological integrity, from 25-39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

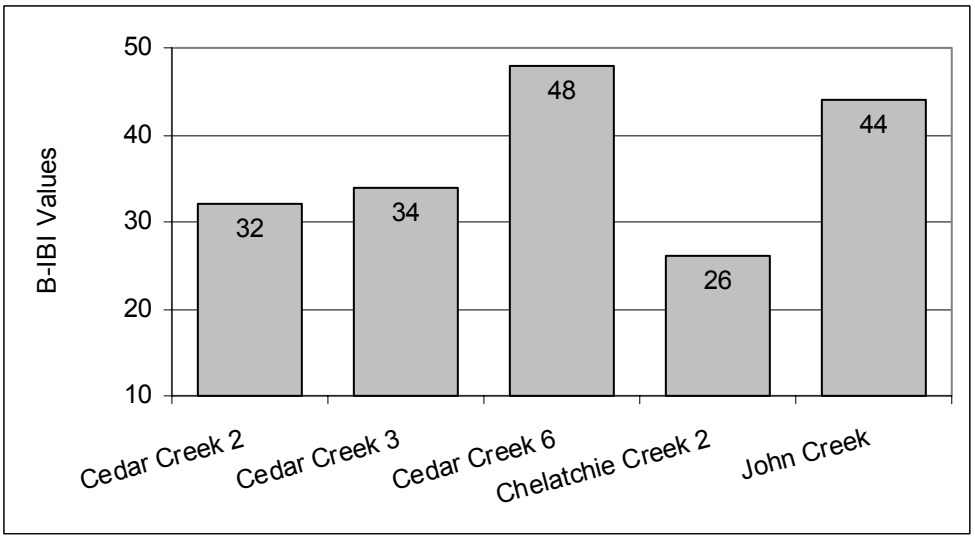

Figure 1-3.Cedar Creek and tributary B-IBI scores in 2004. Scores indicate moderate-to-high biological integrity at the sites sampled.

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score. Sub-index scores are broken down in the individual reach summaries in the following pages. Appendix A provides a basic description of each B-IBI metric and the expected response to stream and watershed degradation.

Macroinvertebrate sampling is usually conducted on riffle habitat within a portion of a single reach; consequently results may not be indicative of the entire stream. However, the cumulative result of upstream land use and management has an impact on conditions at the sampling station. The moderate to high biological integrity in Cedar Creek and its tributaries suggests that human influence on water quality and habitat is assessable. The moderate biological integrity observed mid-watershed in Cedar Creek seems consistent with many of the habitat limitations noted during the habitat surveys. Limited riparian canopy likely has led to high water temperatures. Channel complexity and a general lack of riffle habitat may also limit the diversity of the macroinvertebrate community. High biological integrity in John Creek and in upper Cedar Creek is encouraging. Areas with high biological integrity should be protected from the impacts of forest conversion, as suggested in the habitat assessment reports. While the station monitored in Chelatchie Creek reach 2 approached poor biological integrity, Clark County's long term monitoring station at the mouth of Chelatchie Creek showed higher biological integrity. Several measurements of the macroinvertebrate community used to calculate the B-IBI were influenced by a disproportionately high number of snails in Chelatchie Creek, which may be an effect of an extensive salmon carcass placement program.

The B-IBI scores reflect impacts to habitat complexity and stability. Based on metric scores and our existing knowledge of water quality conditions, the impacts to benthic macroinvertebrate populations are attributable largely to altered flow regimes and sediment accumulation. Elevated stream temperatures are a known problem and may also be impacting some of the more sensitive taxa.

North Fork Lewis River
Middle Cedar Creek Reaches 2 and 3

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Cedar Creek (Middle))

Area: 19.5 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate to steep, 19.8% average watershed slope
Stream Size: small, 4th order stream
Development: 5.1 acre median parcel size; 6.9% total impervious area; primarily forest and agriculture with low-density residential development
Forest Cover: 57.4% forest land cover

Reach Notes

EDT Tier: 2-3
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 200 feet

Cedar Creek reaches 2 and 3 have similar habitat characteristics. Cedar Creek 2 extends from Pup Creek (RM4.3) to John Creek (RM7.7). Cedar Creek 3 extends from John Creek to Brush Creek (RM9.3). Both reaches have narrow, low-gradient floodplain channels located in a wide, glacial-till outwash valley. The reaches have low to moderate energy with gradients of 1.5%. Throughout this section, Cedar Creek's channel appeared very responsive to large wood, although higher stream energy during high flows may make it difficult to keep wood in place. Small cobble/gravel riffles were the dominant habitat types. Both reaches had somewhat equal distributions of gravel and cobble, with some sand embeddedness.

Table 1-2. Cedar Creek 2 and 3 channel characteristics.

Characteristic	Cedar Creek 2 Value	Cedar Creek 3 Value
Gradient	1.5%	1.5%
Wetted Width	15.3 m	13.0 m
Bankfull Width	17.8 m	15.8 m
Primary Habitat	Small cobble/gravel riffle	Small cobble/gravel riffle
Secondary Habitat	Pool	Pool

Table 1-3. Cedar Creek 2 and 3 substrate characteristics.

Characteristic	Cedar Creek 2 Value	Cedar Creek 3 Value
Sand	11%	15%
Gravel	34%	39%
Cobble	38%	34%
Boulder	18%	12%
Bedrock	0%	0%
Embeddedness	28%	29%
D50	NA	NA
D90	NA	NA

Water temperature in Cedar Creek reaches 2 and 3 was about 10 deg-F higher than target criteria of 64 deg-F in 2004 (Table 1-4 below). The observed temperatures were above the target criteria for over 50 days during July and August. Habitat survey reports noted that the unconfined channel in both reaches was largely open to the sky, with typical riparian disturbance zones extending 50-60 meters from the creek's center. Reach 2 had mostly mixed conifer/ hardwood stands, while reach 3 riparian stands were primarily hardwood with fewer amounts of conifer. Typical view to sky values were about 40% open, much higher than observed in upstream reaches where measured water temperatures were lower.

Table 1-4. Cedar Creek 2 and 3 water temperature measurements.

Characteristic	Cedar Creek 2	Cedar Creek 3
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	74 deg-F	74 deg-F
Date of Max 7-DAD	8/12/04	8/12/04
Duration greater than 64 deg-F	57	55

The B-IBI scores indicated moderate biological integrity in Cedar Creek reaches 2 and 3. Measurements receiving low ratings included numbers of pollution intolerant species and the percent of predator species in reach 3. A number of mayfly and stonefly species were present indicating good water quality and habitat conditions. Also, the macroinvertebrate communities did not have relatively high percentages of pollution tolerant species, although a higher percentage was noted in Cedar Creek 2 along with fewer total taxa.

One or two sub-index scores were near the upper end of the ranges and may improve biological ratings with marginal increases in habitat conditions. Examples include the number of mayfly and stonefly taxa and overall sample dominance, which scored near the high ratings. Improvements to habitat complexity and lower water temperatures will help increase biological diversity.

Table 1-5. Cedar Creek 2 macroinvertebrate community metrics from 10/14/04 survey; Figure 1-1 shows the location of the water quality station CED050.

BIBI Metrics	Value	Score
Total number of taxa	35	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	4	moderate
Number of Caddisfly taxa	6	moderate
Number of long-lived taxa	5	high
Number of intolerant taxa	0	low
Percent tolerant taxa	43%	moderate
Percent predator taxa	12%	moderate
Number of clinger taxa	24	high
Percent dominance (three taxa)	54%	moderate
Total BIBI score	**32**	**moderate**

Table 1-6. Cedar Creek 3 macroinvertebrate community metrics from 10/14/04 survey; Figure 1-1 shows the location of the water quality station CED055.

BIBI Metrics	Value	Score
Total number of taxa	44	high
Number of Mayfly taxa	8	moderate
Number of Stonefly taxa	7	moderate
Number of Caddisfly taxa	5	moderate
Number of long-lived taxa	6	high
Number of intolerant taxa	1	low
Percent tolerant taxa	27%	moderate
Percent predator taxa	7%	low
Number of clinger taxa	30	high
Percent dominance (three taxa)	41%	high
Total BIBI score	**34**	**moderate biological integrity**

North Fork Lewis River
John Creek (tributary to Cedar Creek 2)

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Cedar Creek (Middle))

Area: 19.5 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate to steep, 19.8% average watershed slope
Stream Size: small, 4th order stream
Development: 5.1 acre median parcel size; 6.9% total impervious area; primarily forest and agriculture with low-density residential development
Forest Cover: 57.4% forest land cover

Reach Notes

EDT Tier: 4
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 375 feet

John Creek is a tributary to Cedar Creek at the upper boundary of reach 2 (RM 7.7) and is part of the Cedar Creek (Middle) subwatershed. John Creek flows through a narrow, v-shaped valley extending to the northeast from the mainstem of Cedar Creek. The creek is small and steep, flowing in a mostly contained channel with bedforms consisting of step-pool sequences. The predominant habitat types consisted of cascades and riffles formed by larger-sized substrate. John Creek has a gradient of over 5% and has high energy capable of moving sediment, therefore large wood and other flow obstructions are important for storing sediment. Sand particles were the most common substrate, followed by an equal distribution of gravel, cobble, and boulder.

Table 1-7. John Creek channel characteristics.

Gradient	5.5%
Wetted Width	4.4 m
Bankfull Width	4.9 m
Primary Habitat	Cascade
Secondary Habitat	Large cobble/boulder riffle

Table 1-8. John Creek substrate characteristics.

Characteristic	Cedar Creek 2 Value
Sand	48%
Gravel	17%
Cobble	20%
Boulder	14%
Bedrock	1%
Embeddedness	56%
D50	48 mm
D90	180 mm

No water temperature data was recorded in this reach in 2004. The surveyed portion John Creek was relatively open to the sky, although canopy coverage was higher in the lower portion of the reach where the channel was confined. Riparian stands were mostly conifer along both banks.

Table 1-9. John Creek water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	NA
Date of Max 7-DAD	NA
Duration greater than 64 deg-F	NA

The B-IBI score indicated high biological integrity in John Creek. There were no scores receiving low ratings and only a few moderate ratings. Several pollution intolerant species were observed in the sample. A high number of stonefly and caddisfly species were present indicating good water quality and habitat conditions. Habitat availability and water temperature may influence some richness and composition metrics, particularly the number of mayfly taxa. The macroinvertebrate community had a moderate percentage of pollution tolerant species.

Two sub-index scores were near the upper end of the ranges and may improve biological ratings with marginal increases in habitat conditions. They include the number of mayfly taxa and percent tolerant taxa, which scored near the thresholds for higher ratings. Improvements to habitat complexity and lower water temperatures will help increase biological diversity.

Table 1-10. John Creek macroinvertebrate community metrics from 10/27/04 survey; Figure 1-1 shows the location of the water quality station JON010.

BIBI Metrics	Value	Score
Total number of taxa	43	high
Number of Mayfly taxa	8	moderate
Number of Stonefly taxa	9	high
Number of Caddisfly taxa	12	high
Number of long-lived taxa	8	high
Number of intolerant taxa	4	high
Percent tolerant taxa	20%	moderate
Percent predator taxa	16%	moderate
Number of clinger taxa	26	high
Percent dominance (three taxa)	40%	high
Total BIBI score	**44**	**high biological integrity**

North Fork Lewis River
Cedar Creek Reach 6

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Cedar Creek (Upper))

Area: 13.8 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate to steep, 19.7% average watershed slope
Stream Size: small, 3rd order stream
Development: 5.2 acre median parcel size; 8.7% total impervious area; primarily public and commercial forest with some low-density residential development
Forest Cover: 50% forest land cover

Reach Notes

EDT Tier: 3
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 300 feet

Only about 0.5 miles of Cedar Creek 6 was surveyed near where the creek intersects Amboy Road, just north of Yacolt, Washington. Cedar Creek 6 is located in the upper Cedar Creek watershed, extending from about the confluence with Chelatchie Creek (RM11.1) to the upper end of the anadromous fish range (RM17.9). The creek flows through a narrow valley in a moderate-gradient, mixed-control type channel. The creek has moderate to high confinement in the valley and has a gradient of about 2%. There was abundant large wood representing all size classes throughout the reach, which for this channel type is very important for sediment storage and pool formation. The reach's primary habitat type was small cobble/gravel riffles and the primary substrate size category was gravel, although a large amount of sand sized particles was observed.

Table 1-11. Cedar Creek 6 channel characteristics.

Characteristic	Cedar Creek 3 Value
Gradient	2.0%
Wetted Width	9.2 m
Bankfull Width	10.9 m
Primary Habitat	Small cobble/gravel riffles
Secondary Habitat	Pools

Table 1-12. Cedar Creek 6 substrate characteristics.

Characteristic	Cedar Creek 3 Value
Sand	32%
Gravel	48%
Cobble	10%
Boulder	10%
Bedrock	0%
Embeddedness	42%
D50	17 mm
D90	60 mm

Two dataloggers were deployed in Cedar Creek 6 in 2004, one located in the bottom third of the reach just above Amboy and the other in the upper third above Amboy Road near Yacolt (Figure 1-1). Water temperature in 2004 was above the target criteria of 64 deg-F for nearly 40 days at both stations, although the magnitude of exceedances was much lower than observed downstream. Reach 6 had relatively good riparian conditions, although areas where the valley was less confined had been cleared for residential development and some timber harvest. The stream was well shaded with primarily hardwood and mixed stands and the view to sky was 13% open, much lower than observed in the creek below Amboy. Maximum water temperature was actually lower in the downstream end of the reach, indicating some cooling had taken place under the riparian canopy or due to groundwater inflow. Timber harvest and low-density residential development may threaten riparian conditions in the upper reach and may have already influenced the elevated water temperatures observed in 2004.

Table 1-13. Cedar Creek 6 water temperature measurements; Cedar 6a and Cedar 6b refer to downstream and upstream water quality stations, respectively (Figure 1-1).

Characteristic	Cedar 6a	Cedar 6b
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	67.1	68.2
Date of Max 7-DAD	7/25/04	8/13/04
Duration greater than 64 deg-F	36	38

The B-IBI score from a sample collected in the upper portion of the reach indicated high biological integrity in Cedar Creek 6. There were no scores receiving low ratings and only one moderate rating for the percent of predator taxa, which scored very near the threshold for a higher rating. Several pollution intolerant species were observed in the sample and the percent of tolerant taxa was very low. A high number of mayfly, stonefly and caddisfly species were present indicating good water quality and habitat conditions.

Several sub-index scores were near the lower end of the ranges therefore biological ratings should be protected with marginal increases in habitat conditions. Examples include the number of mayfly taxa and percent predator taxa, which scored near the thresholds for moderate ratings. Improvements to habitat complexity and decreasing water temperatures will help protect the outstanding biological diversity observed in Cedar Creek 6.

Table 1-14. Cedar Creek 6 macroinvertebrate community metrics from 10/27/04 survey; Figure 1-1 shows the location of the water quality station CED080.

BIBI Metrics	Value	Score
Total number of taxa	42	high
Number of Mayfly taxa	9	high
Number of Stonefly taxa	8	high
Number of Caddisfly taxa	11	high
Number of long-lived taxa	7	high
Number of intolerant taxa	4	high
Percent tolerant taxa	7	high
Percent predator taxa	20	moderate
Number of clinger taxa	25	high
Percent dominance (three taxa)	41	high
Total BIBI score	**48**	**high biological integrity**

North Fork Lewis River
Chelatchie Creek Reach 2

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Chelatchie Creek)

Area: 12.7 square miles
Hydrogeology: mostly older rock/bedrock hill slopes with unconsolidated sedimentary rock in the valley
Topography: moderate to steep, 23.4% average watershed slope; valley floor is very flat
Stream Size: small, 4th order stream
Development: 5.3 acre median parcel size; 8.6% total impervious area; primarily forest and agriculture with low-density residential development
Forest Cover: 50.0% forest land cover

Reach Notes

EDT Tier: 4
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 250 feet

Chelatchie Creek 2 is located near the confluence with the North Fork Chelatchie Creek (RM0.5) upstream to the community of Chelatchie Prairie (RM4.8). Approximately 0.75 miles of the lower portion of the reach was surveyed. Chelatchie Creek flows across the Chelatchie Prairie, a wide, open valley formed of glacial outwash. The stream has very low gradient and energy, and meanders across the valley floor. The channel type is an unconfined Palustrine channel, with many features most likely a result of historical beaver activity. Bedforms associated with Palustrine channels are oscillating dune-ripple sequences formed of sand and small gravel, or weakly developed pool-riffle sequences where the gradient steepens. Sand and gravel sized substrates were dominant.

Large wood was abundant and important for fish cover but not for pool formation or sediment storage as the river most likely cuts under or around flow obstructions. Pools and glides were the most common habitat features throughout the reach.

Table 1-15. Chelatchie Creek 2 channel characteristics.

Characteristic	Cedar Creek 3 Value
Gradient	0.5%
Wetted Width	6.6 m
Bankfull Width	7.8 m
Primary Habitat	Pools
Secondary Habitat	Glide

Table 1-16. Chelatchie Creek 2 substrate characteristics.

Characteristic	Cedar Creek 3 Value
Sand	44%
Gravel	50%
Cobble	5%
Boulder	1%
Bedrock	0%
Embeddedness	66%
D50	17 mm
D90	60 mm

Water temperature, measured near mid-reach just downstream of Gerber-McKee Road, was below the target criteria of 64 deg-F (Table 1-17). Chelatchie 2 has relatively good riparian conditions, although the portion of the reach surveyed may not be representative of the entire reach where extensive agricultural development has exposed much of the creek and bank. Riparian stands are chiefly hardwood with some mixed stands in the lower reach near the confluence with the North Fork branch. The view to sky was about 20% open. Seeps and springs are abundant in the valley, accounting for the low water temperatures observed. Water temperature recorded at Clark County's long term monitoring station at the mouth of Chelatchie Creek indicated that some warming occurs below this reach.

Table 1-17. Chelatchie Creek 2 water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	62.7
Date of Max 7-DAD	7/26/04
Duration greater than 64 deg-F	0

The B-IBI score indicated low-moderate biological integrity in Chelatchie Creek 2. There were several scores receiving low ratings including number of intolerant taxa and percent tolerant and predator taxa. A number of mayfly, stonefly, and caddisfly species were present indicating good water quality and habitat conditions. Habitat availability may influence some richness and composition metrics, particularly the number of intolerant taxa. The macroinvertebrate community did not have a very high percentage of pollution tolerant species.

There were a surprising number of snails in the sample, comprising over 50% of the 500+ organisms identified. This dominance of snails impacts the percentage-based metrics in the B-IBI score. A local fish-enhancement group was conducting an active salmon carcass placement program at the time of the sample. There is likely an effect on the local macroinvertebrate community, potentially concentrating these coarse material decomposers around areas where carcasses are distributed or accumulate. Much higher biological integrity was observed at Clark County's long term monitoring station at the mouth of Chelatchie Creek in 2004. But that station also had a high number of snails in the sample.

The habitat survey noted that prominent algal growth and other signs of eutrophication seen in Chelatchie Creek seem to reflect agricultural and rural land use practices and the creek does not appear to be nutrient-limited (LCFRB, 2004). It was not clear if carcass placement to provide marine-derived nutrients is achieving the desired results. Placing salmon carcasses may also affect the macroinvertebrate community but more monitoring would need to be done to determine the specific impact.

Table 1-18. Chelatchie Creek 2 macroinvertebrate community metrics from 10/6/04 survey; Figure 1-1 shows the location of the water quality station CHL030.

BIBI Metrics	Value	Score
Total number of taxa	39	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	7	moderate
Number of Caddisfly taxa	9	moderate
Number of long-lived taxa	7	high
Number of intolerant taxa	0	low
Percent tolerant taxa	60	low
Percent predator taxa	8	low
Number of clinger taxa	19	moderate
Percent dominance (three taxa)	65	moderate
Total BIBI score	**26**	**moderate biological integrity**

Section 2 - East Fork Lewis River Watershed Summary

Conditions and Opportunities (from Lower Columbia Fish Recovery Board, Dec. 2004. Kalama, Washougal and Lewis River Habitat Assessments: Chapter 4: The East Fork Lewis River Basin)

Strengths, weaknesses, and restoration opportunities summary

- *Lower Mainstem East Fork Lewis River*
    - Preservation Opportunities
        - Protect riparian forests and flood plains in the valley bottom
    - Restoration Opportunities
        - Remove hydro-modifications
        - Reduce severe bank instability
        - Create/restore side channel and off-channel habitats
        - Restore riparian forests
        - Restore in-stream structure, rock and wood
- *Lower Mainstem Tributary Basins (McCormick, Jenny, Brezee, Lockwood, Mason Creeks)*
    - Preservation Opportunities
        - Acquire lands in lower segments of tributaries for projects
        - Implement development regulations (county and city)
    - Restoration Opportunities
        - Restore/remove passage barriers
        - Restore riparian forests
        - Reclaim agriculture and open space lands
        - Control stormwater runoff
        - Remove hydro-modifications
        - Eradicate invasive species
- *Middle Mainstem East Fork Lewis River*
    - Preservation Opportunities
        - Protect riparian corridors and stream channels
    - Restoration Opportunities
        - Mitigate road impacts and bank armoring along stream
        - Eradicate invasive species
        - Restore hill slope processes affected by development (e.g. erosion)
        - Restore riparian forests
        - Restore in-stream structure
- *Upper North Side Tributary Basins (Yacolt, Big Tree ,Rogers, Niccolls, and Anaconda Creeks*
    - Preservation Opportunities
        - Protect riparian corridors and hill slope process
    - Restoration Opportunities
        - Restore riparian forests
        - Restore hill slope processes affected development (e.g. erosion)
- *Upper South Side Tributary Basins (Rock, King, and Copper Creeks)*
    - Preservation Opportunities
        - Protect riparian corridors and stream channels
        - Protect hill slope conditions
    - Restoration Opportunities
        - Restore riparian forests
        - Supplement large wood
        - Stabilize banks that have stream-adjacent roadways

Data Summary for the East Fork Lewis River Watershed

During the 2004 field season, habitat surveys were conducted by SP Cramer & Associates, Inc. in twenty two EDT reaches in the East Fork Lewis River watershed, including both mainstem and tributary reaches. Figure 2-1 below shows the locations of the surveyed reaches.

Utilizing the efforts of trained volunteers and staff from Clark Public Utilities, Water Resources coordinated the deployment of six water temperature data loggers in East Fork Lewis River tributaries. Data was not recovered from two data loggers. The Upper Rock Creek data logger deployed by Water Resources was lost, and the Lockwood Creek data logger deployed by CPU failed to collect data.

Also with the help of volunteers and CPU staff, seven benthic-macroinvertebrate samples were collected from stations on the mainstem and tributaries. In two instances, Mill Creek and Mason Creek, volunteers and CPU staff collected both macroinvertebrate and habitat data, however, habitat surveys were not performed using the USFS protocol by the consultant.

In all, water quality and habitat surveys were completed in only one EDT reach, Lower Rock Creek, with partial surveys completed in eight other reaches.

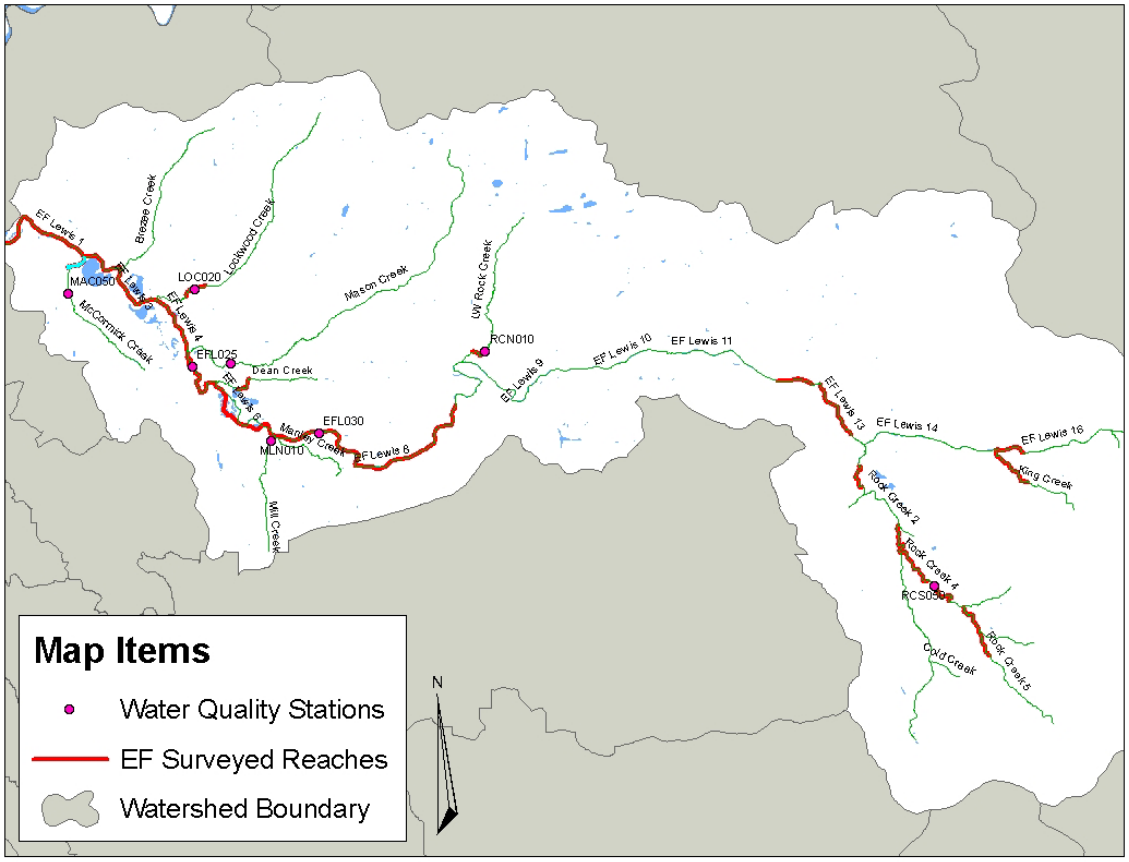

Figure 2-1. Map of the Lower East Fork Lewis watershed showing the reaches surveyed and locations of the water quality monitoring stations; macroinvertebrate samples were collected from the following stations: LOC020, RCN010, RCS050, MAS020, MLN010, EFL025, and EFL030.

Water Temperature Summary

Table 2-1 summarizes the continuous water temperature data for the East Fork Lewis River watershed stations that were monitored in 2004. The summary value is the maximum of the 7-day moving average of daily maximum temperatures. The 2003 Washington State water quality standards, currently under EPA review, utilize this metric to determine temperature compliance. The duration greater than 64 deg-F indicates the number of days on which the *daily* maximum temperature exceeded the 64° F criterion. Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent out of compliance is also of interest.

A relatively minor amount of water temperature data was collected in the East Fork Lewis River watershed in 2004 and a more complete dataset is required to discuss widespread conditions and impacts (Note: The Washington State Department of Ecology is conducting watershed-wide temperature monitoring in 2005 for developing a TMDL). During 2004, high water temperatures were observed in several lower mainstem East Fork Lewis River tributaries (Table 2-1; Figure 2-2). Water temperatures were higher than the target criteria at nearly all stations, with values below the target criteria observed only in Mill Creek. Lower Rock Creek had very high water temperature in late July, over 10 degrees higher than the target criteria. Many stations had high water temperatures lasting for over two months during the mid to late-summer.

Elevated temperature data relates to sparse riparian vegetation and a lack of shading of the stream channel, particularly in the lower reaches of the mainstem and its tributaries. In general, much of the area over the river channel was open to the sky, due in part to wide channels and floodplain but also due to vegetation removal. Higher amounts of forest cover in the upper tributaries most likely result in lower water temperatures relative to the lower tributaries, although values may still be at levels that are harmful to aquatic life. Controlling channel width and providing shade to the lower mainstem East Fork Lewis River are critical to reducing water temperatures.

Table 2-1. East Fork Lewis River tributary water temperature data summary, summer 2004; the reaches are roughly ordered from upstream to downstream.

EDT Reach Name	Date	7-DAD Max Temperature	Duration > 64 deg-F
McCormick Creek	7/25/2004	70.4 deg-F	70 days
Mason Creek	7/25/2004	71.2 deg-F	68 days
Mill Creek	7/25/2004	61.4 deg-F	0 days
LW Rock Creek	7/24/2004	75.2 deg-F	67 days

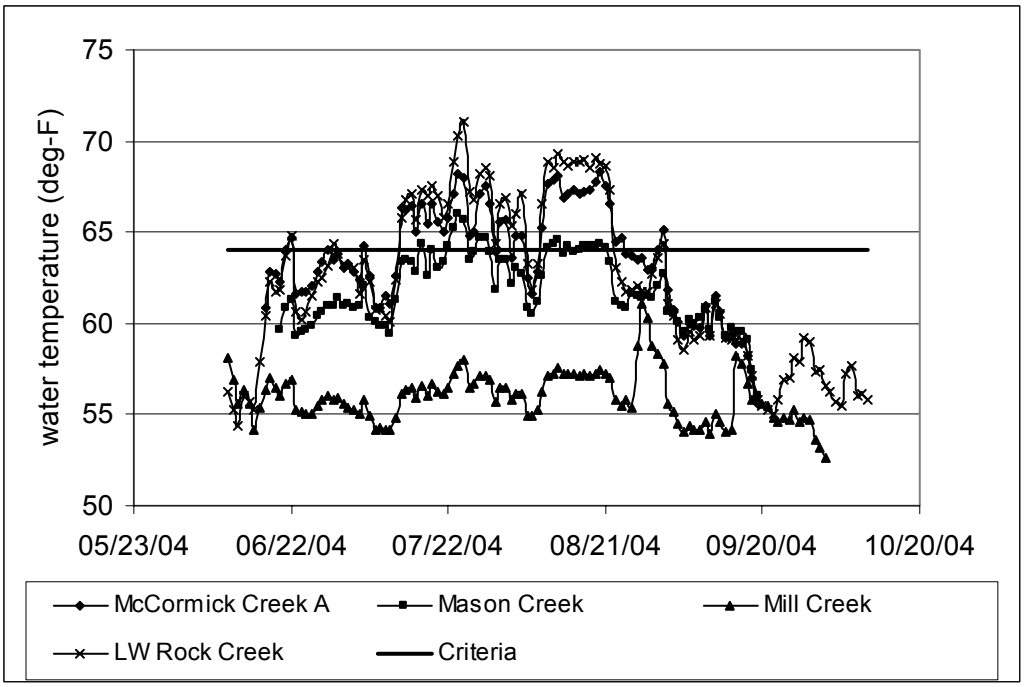

Figure 2-2. East Fork Lewis River water temperatures, as depicted by the 7-DADMax value, measured in 2004; a criterion shown is the 64-deg F target.

Biological Survey Summary

Water Resources utilizes the widely applied Benthic Macroinvertebrate Index of Biological Integrity, or B-IBI (Karr, 1998), to measure the health of streams based on the macroinvertebrate population.

Karr's B-IBI is based on ten metrics that describe various aspects of stream biology, including tolerance and intolerance to pollution, taxonomic richness, feeding ecology, reproductive strategy, and population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species are often the most sensitive to disruption and will be the first to disappear from a stream as human disturbance increases.

The raw data value for each metric are converted to a score of 1, 3, or 5, and the ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10-24 indicate low biological integrity, from 25-39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

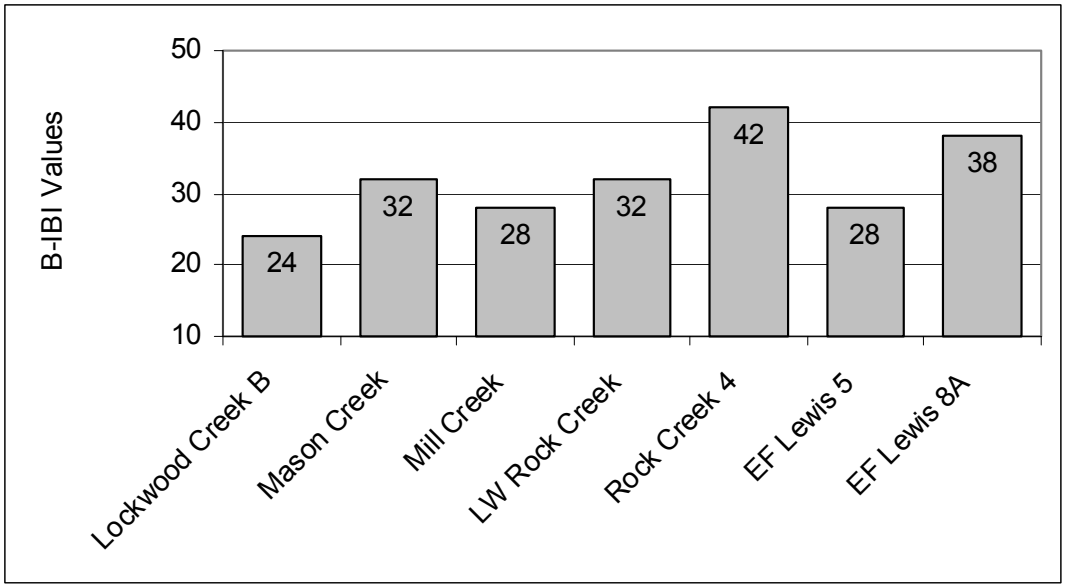

Figure 2-3.East Fork Lewis River B-IBI scores in 2004. Scores indicated a wide range of biological integrity from low-to-high scores at the stations sampled.

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score. Sub-index scores are broken down in the individual reach summaries in the following pages. Appendix A provides a basic description of each B-IBI metric and the expected response to stream and watershed degradation.

Macroinvertebrate sampling is usually conducted on riffle habitat within a portion of a single reach; consequently results may not be indicative of the entire stream. However, the cumulative result of upstream land use and management has an impact on conditions at the sampling station. The biological integrity scores in the lower East Fork Lewis River watershed suggest that human influence on water quality and habitat is assessable and substantial, particularly in the lower watershed. Biological integrity scores in the lower mainstem near Dean Creek and in several tributaries were low-to-moderate. The list of potential problems and restoration opportunities in the lower watershed is not concise and, coupled with impairments in biological integrity, underpin the need for improvement.

The moderate-to-high biological integrity observed near Daybreak Park at EF Lewis 8A seems consistent with many of the habitat limitations noted during the habitat surveys. High biological integrity in Upper Rock Creek is encouraging. Areas with high biological integrity should be protected from the impacts of forest conversion, as suggested in the habitat assessment reports.

The B-IBI scores reflect impacts to habitat complexity and stability. Based on metric scores and our existing knowledge of water quality conditions, the impacts to benthic macroinvertebrate populations are attributable largely to altered flow regimes and sediment accumulation. Elevated stream temperatures are a known problem and may also be impacting some of the more sensitive taxa.

East Fork Lewis River
East Fork Lewis Reach 5

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (East Fork Lewis (RM 3.19))

Area: 8.4 square miles
Hydrogeology: mix of unconsolidated sedimentary rock/deposits and Troutdale gravel
Topography: subtle to moderate, 8.8% average watershed slope
Stream Size: large, 6th order stream
Development: 4.9 acre median parcel size; 15.0% total impervious area; agriculture with some low-density residential development, public land ownership.
Forest Cover: 22.9% forest land cover

Reach Notes

EDT Tier: 1
Ecoregion: Level 4 Ecoregion 3a Portland/Vancouver Basin
Elevation: 20 feet

The entire length (1.6 miles) of East Fork Lewis reach 5 was surveyed by boat using a modified version of the habitat survey protocol. Reach 5 is located in the lower watershed, extending from about the confluence with Mason Creek to Dean Creek. Reach 5 is a transitional reach between the pool-riffle morphology upstream and the tidewater habitat below. It is primarily pool habitat. As with most of the lower river reaches, the gradient is very low (0.3%) and the channel is naturally unconfined but artificially confined by hydromodifications such as dikes and levees.

Wood availability is limited, only about 50 pieces per mile mostly representing the small to medium size category (< 50 cm diameter). The primary substrate size category was gravel and cobble, although a large amount of sand-sized particles was observed. Pebble counts revealed that the median size class in pool tailouts was 22.6-32 mm. Embeddedness was determined to be relatively low, about 20% according to visual estimates.

Table 2-2. East Fork Lewis 5 channel characteristics.

Characteristic	Value
Gradient	0.3%
Wetted Width	20.3 m
Bankfull Width	36.1 m
Primary Habitat	Pools
Secondary Habitat	Small cobble/gravel riffle

Table 2-3. East Fork Lewis 5substrate characteristics.

Characteristic	Value
Sand	7%
Gravel	70%
Cobble	22%
Boulder	0%
Bedrock	0%
Embeddedness	20%
D50	27.3 mm
D90	77 mm

No water temperature data was collected from this reach in 2004. Although temperature was not monitored, the habitat surveys revealed that shade was limited because of the width of both the river and the valley bottom. The primary vegetation type in reach 5 is hardwood or mixed hardwood/conifer, followed by saplings and shrubs that provided limited shade.

Table 2-4. East Fork Lewis 5 water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	NA
Date of Max 7-DAD	NA
Duration greater than 64 deg-F	NA

The B-IBI score indicated low-to-moderate biological integrity in East Fork Lewis 5. There were two scores receiving low ratings, including the number of intolerant taxa and the percent predator taxa. No pollution intolerant species were observed in the sample and the percent of tolerant taxa was nearly 35%. About 30% of the species present were classified as sediment tolerant. Only moderate numbers of mayfly, stonefly and caddisfly species were present indicating degrading water quality and habitat conditions.

Most of the sub-index scores were in the middle of the metric ranges, therefore biological ratings may be resistant to marginal increases in habitat conditions. Percent dominance nearly received a poor rating due to the high numbers of non-insect taxa, primarily snails, which accounted for nearly 30% of the insects identified. Improvements to habitat complexity and decreasing water temperatures, both in this reach and upstream, should help increase the biological diversity in East Fork Lewis 5.

Table 2-5. East Fork Lewis 5 macroinvertebrate community metrics from 9/24/04 survey; Figure 2-1 shows the location of the water quality station EFL025.

BIBI Metrics	Value	Score
Total number of taxa	33	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	5	moderate
Number of Caddisfly taxa	6	moderate
Number of long-lived taxa	5	high
Number of intolerant taxa	0	low
Percent tolerant taxa	34%	moderate
Percent predator taxa	7%	low
Number of clinger taxa	11	moderate
Percent dominance (three taxa)	74%	moderate
Total BIBI score	**28**	**moderate biological integrity**

East Fork Lewis River
East Fork Lewis Reach 8A

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (East Fork Lewis (RM 7.25))

Area: 10.6 square miles
Hydrogeology: mix of unconsolidated sedimentary rock/deposits and Troutdale gravel
Topography: subtle to moderate, 8.5% average watershed slope
Stream Size: large, 6th order stream
Development: 2.6 acre median parcel size; 19.3% total impervious area; low-density residential development and agriculture, public land ownership
Forest Cover: 36.1% forest land cover

Reach Notes

EDT Tier: 1
Ecoregion: Level 4 Ecoregion 3a Portland/Vancouver Basin
Elevation: 70 feet

The original EDT East Fork Lewis reach 8 was subdivided because of significant changes in channel morphology and habitat conditions observed during the habitat survey. The entire length (3.7 miles) of East Fork Lewis reach 8A was surveyed by boat using a modified version of the habitat survey protocol. Reach 8A is located in the lower watershed, extending from about the confluence with Manley Creek upstream to the SR503 bridge at Lewisville Park. Reach 8A has pool-riffle morphology, with both small and large substrate riffles the primary habitat type. As with most of the lower river reaches, the gradient is very low (0.4%) and the channel is naturally unconfined but in places artificially confined by hydromodifications.

Wood availability is very limited, with only about 13 pieces per mile, mostly representing the small to medium size category (< 50 cm diameter). The primary substrate size category was gravel and cobble, with some sand-sized particles observed. Pebble counts revealed that the median size class in pool tail-outs was 45-64 mm. Embeddedness was determined to be relatively low, about 20% according to visual estimates.

Table 2-6. East Fork Lewis 8A channel characteristics.

Characteristic	Value
Gradient	0.4%
Wetted Width	29.5 m
Bankfull Width	47.0 m
Primary Habitat	Large/small substrate riffles
Secondary Habitat	Pools

Table 2-7. East Fork Lewis 8A substrate characteristics.

Characteristic	Value
Sand	6%
Gravel	48%
Cobble	36%
Boulder	10%
Bedrock	0%
Embeddedness	20%
D50	54.3 mm
D90	218 mm

No water temperature data was collected from this reach in 2004. Although temperature was not monitored, the habitat surveys revealed that shade is limited because of the width of both the river and the valley bottom. The primary vegetation type in reach 8A is hardwood and mixed hardwood/conifer, with some conifers on the south bank providing shade.

Table 2-8. East Fork Lewis 8 water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	NA
Date of Max 7-DAD	NA
Duration greater than 64 deg-F	NA

The B-IBI score indicated moderate-to-high biological integrity in East Fork Lewis 8A, which is encouraging considering that the sample station is in the lower part of the watershed. There was a single score receiving a low rating for the number of intolerant taxa, although, there were two sensitive taxa present in the sample. The percent tolerant taxa score was about 23%, near the threshold of 20% for a higher rating. High numbers of numbers of stonefly and caddisfly species were present, indicating good water quality and habitat conditions. However, only a moderate number of mayfly taxa were identified and the overall taxa richness received a moderate score, near the threshold for a higher rating.

Improvements to habitat complexity and lower water temperatures will help increase biological diversity. Biological ratings may increase with marginal increases in habitat conditions locally; however, upstream improvements in water quality, specifically water temperature, should help increase diversity.

Table 2-9. East Fork Lewis 8A macroinvertebrate community metrics from 9/24/04 survey; Figure 2-1 shows the location of the water quality station EFL030.

BIBI Metrics	Value	Score
Total number of taxa	37	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	10	high
Number of Caddisfly taxa	10	high
Number of long-lived taxa	10	high
Number of intolerant taxa	2	low
Percent tolerant taxa	23%	moderate
Percent predator taxa	14%	moderate
Number of clinger taxa	23	high
Percent dominance (three taxa)	22%	high
Total BIBI score	**38**	**moderate biological integrity**

East Fork Lewis River
Lockwood Creek B

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Lockwood Creek)

Area: 7.9 square miles
Hydrogeology: mostly Troutdale gravel with some older rock in the headwaters
Topography: moderate, 14.3% average watershed slope
Stream Size: small, 3rd order stream
Development: 5.1 acre median parcel size; 10.3% total impervious area; mix of low density residential and agriculture, public land ownership.
Forest Cover: 45.0% forest land cover

Reach Notes

EDT Tier: 2
Ecoregion: Level 4 Ecoregion 3d Willamette valley foothills
Elevation: 30 feet

Just over 10% (0.5 miles) of the total length of Lockwood Creek reach B was surveyed using the habitat survey protocol. Lockwood Creek B is tributary to the lower East Fork Lewis River at about RM 4.5, just southwest of La Center. The creek has pool-riffle morphology and is dominated by beaver ponds at the downstream end. It is primarily pool habitat, followed by small sized substrate riffles and beaver ponds. As with most of the lower river tributaries, the gradient is very low (0.7%) and the channel is naturally unconfined, although some entrenchment was observed.

Wood availability is limited, with about 56 pieces per mile, mostly representing the small size category. The primary substrate size category was gravel, although a large amount of sand-sized particles was observed. Pebble counts revealed that the median size class in pool tail-outs was 22.6-32 mm. Embeddedness by sand was determined to be relatively high, about 50% according to visual estimates.

Table 2-10. Lockwood Creek B channel characteristics.

Characteristic	Value
Gradient	0.7%
Wetted Width	5.5 m
Bankfull Width	7.1 m
Primary Habitat	Pools
Secondary Habitat	Small cobble/gravel riffle

Table 2-11. Lockwood Creek B substrate characteristics.

Characteristic	Value
Sand	18%
Gravel	73%
Cobble	10%
Boulder	0%
Bedrock	0%
Embeddedness	50%
D50	27 mm
D90	77 mm

A water temperature data logger deployed in Lockwood Creek by CPU failed to launch, therefore no temperature data was collected in 2004. Although temperature was not monitored, the habitat surveys revealed that shade was limited because of the width of the valley bottom and the presence of wetlands that may inhibit growth of near-stream overstory. The primary vegetation type along Lockwood Creek is hardwood or mixed hardwood/conifer, followed by saplings and shrubs that provided limited shade.

Table 2-12. Lockwood Creek B water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	NA
Date of Max 7-DAD	NA
Duration greater than 64 deg-F	NA

The B-IBI score indicated low biological integrity in Lockwood Creek. There were four scores receiving low ratings, including the number of intolerant taxa, the percent tolerant taxa, and the percent predator taxa. The number of caddisfly taxa also received a low rating. No pollution intolerant species were observed in the sample and the percent of tolerant taxa was over 50%. About 38% of the macroinvertebrates identified were classified as sediment tolerant. Only moderate numbers of mayfly and stonefly were present indicating degrading water quality and habitat conditions.

Most of the sub-index scores were in the middle of the ranges for biological ratings, therefore overall ratings may be resistant to marginal increases in habitat conditions. Percent tolerant taxa and the number of mayfly taxa were near the upper thresholds for a higher rating. Improvements to habitat complexity and decreasing water temperatures, both in this reach and upstream, should help increase the biological diversity in Lockwood Creek. Sand embeddedness was high and likely impairs macroinvertebrate diversity, therefore, controlling sediment input and bank erosion is central to increasing biological ratings.

Table 2-13. Lockwood Creek B macroinvertebrate community metrics from 10/12/2004 survey; Figure 2-1 shows the location of the water quality station LOC020.

BIBI Metrics	Value	Score
Total number of taxa	28	moderate
Number of Mayfly taxa	7	moderate
Number of Stonefly taxa	5	moderate
Number of Caddisfly taxa	4	low
Number of long-lived taxa	7	high
Number of intolerant taxa	0	low
Percent tolerant taxa	53%	low
Percent predator taxa	8%	low
Number of clinger taxa	14	moderate
Percent dominance (three taxa)	61%	moderate
Total BIBI score	**24**	**low biological integrity**

East Fork Lewis River
LW Rock Creek

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Rock Creek North**)**
Area: 13.5 square miles
Hydrogeology: mostly older bedrock in the headwaters with some Troutdale gravel lower
Topography: moderate, 13.4% average watershed slope
Stream Size: small, 4th order stream
Development: 5.0 acre median parcel size; 9.6% total impervious area; mix of low density residential and agriculture, including timber.
Forest Cover: 54.4% forest land cover

Reach Notes
EDT Tier: 2
Ecoregion: Level 4 Ecoregion 3d Willamette valley foothills
Elevation: 275 feet

About 11% (0.5 miles) of the total length of LW Rock Creek was surveyed using the habitat survey protocol. LW Rock Creek enters the East Fork Lewis River from the north at about RM 16.1, north of the city of Battle Ground. The creek has pool-riffle morphology and is only moderately confined by the valley walls in the lower reach. The primary habitat type is large cobble/boulder riffle, followed by pools. The channel of LW Rock Creek is steeper than most of the lower river tributaries with a gradient of about 2.0%.

Wood availability is limited, with about 48 pieces per mile, mostly representing the medium size category (20-50 cm diameter). The primary substrate size categories were cobble and gravel, respectively. Pebble counts revealed that the median size class in one riffle was 90-128 mm. Embeddedness by sand was determined to be moderate, about 20% according to visual estimates.

Table 2-14. LW Rock Creek channel characteristics.

Characteristic	Value
Gradient	2.0%
Wetted Width	5.9 m
Bankfull Width	6.8 m
Primary Habitat	Large cobble/boulder riffle
Secondary Habitat	Pools

Table 2-15. LW Rock Creek substrate characteristics.

Characteristic	Value
Sand	5%
Gravel	26%
Cobble	42%
Boulder	27%
Bedrock	0%
Embeddedness	20%
D50	109 mm
D90	437 mm

A water temperature data logger was deployed near the upper end of the surveyed reach. Maximum observed stream temperature in LW Rock Creek exceeded the state criterion by over 10 degrees in 2004 (Table 2-16 below). The duration of exceedances was nearly 70 days during the mid to late summer period. Water temperature recorded at Clark County's long term monitoring station upstream a few miles was lower, indicating that a significant amount of heating takes place between the two stations. Both stream banks were shaded primarily by mixed hardwood and conifer vegetation in the surveyed reach. The riparian understory was dominated by invasive species. Very low flows observed by county staff in 2004 likely limit the ability of the stream to maintain water temperatures below ambient air temperatures.

Table 2-16. LW Rock Creek water temperature measurements; Figure 2-1 shows the location of the water quality station RCN010.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	75.2 deg-F
Date of Max 7-DAD	7/24/2004
Duration greater than 64 deg-F	67 days

The B-IBI score indicated moderate biological integrity in LW Rock Creek. There was only one score receiving a low rating, the number of intolerant taxa. No pollution intolerant species were observed in the sample; however, the percent of pollution tolerant taxa was low. There were no taxa representing a category requiring cold water. Only moderate numbers of mayfly and stonefly taxa were present indicating degrading water quality and habitat conditions.

Many of the biological ratings were near the upper or lower metric thresholds. The number of stonefly taxa and the percent predator taxa were at the lower threshold for receiving a lower rating. The number of long-lived taxa and the number of clinger taxa were at the upper end of the moderate rating category. Improvements to habitat complexity and decreasing water temperatures, both in this reach and upstream, should help increase the biological diversity in LW Rock Creek by stabilizing decreasing ratings. Water temperature was very high and likely impairs stonefly and mayfly diversity; therefore, controlling heat input is central to increasing biological ratings.

Table 2-17. LW Rock Creek macroinvertebrate community metrics from 7/28/2004 survey; Figure 2-1 shows the location of the water quality station RCN010.

BIBI Metrics	Value	Score
Total number of taxa	40	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	4	moderate
Number of Caddisfly taxa	11	high
Number of long-lived taxa	4	moderate
Number of intolerant taxa	0	low
Percent tolerant taxa	1%	high
Percent predator taxa	11%	moderate
Number of clinger taxa	19	moderate
Percent dominance (three taxa)	65%	moderate
Total BIBI score	**32**	**moderate biological integrity**

East Fork Lewis River
Rock Creek

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Rock Creek (South)

Area:	15.7 square miles
Hydrogeology:	Older rock and bedrock
Topography:	moderate to steep, 24.5% average watershed slope
Stream Size:	large, 5th order stream
Development:	9.3 acre median parcel size; 6.1% total impervious area; mostly forest and open space with some low-density residential development
Forest Cover:	85.3% forest land cover

Reach Notes

EDT Tier:	1
Ecoregion:	Level 4 Ecoregion 3a Western Cascades Lowlands and Valley
Elevation:	900 feet

Rock Creek is a significant tributary to the upper East Fork Lewis River at about RM26. Several segments of Rock Creek were surveyed from near the confluence with the East Fork Lewis River to RM6.5. A little over four miles of Rock Creek was surveyed in all, representing about 58% of the total length of the four surveyed reaches combined. About 75% of Rock Creek 4 was surveyed using the habitat survey protocol. Water quality monitoring was conducted only in Rock Creek reach 4.

Rock Creek 4 is located near the Dole Valley Road crossing about mid-watershed, extending downstream to the confluence of Cedar Creek entering from the south. Rock Creek as a whole is confined and has characteristics of cascade, step-pool, and plane-bed channel morphologies. Habitat in reach 4 is primarily large cobble/boulder riffle followed by smaller substrate riffles and pools. Gradient is moderate (1.4%) and channel confinement is also moderate in reach 4, although confinement by bedrock and steep valley walls increases downstream.

Wood availability is higher in reaches 4 and 5 relative to downstream. Predominantly medium sized pieces (20-50 cm diameter) were found at a frequency of about 120 pieces per mile. The primary substrate size category was cobble followed by gravel, with a substantial amount of bedrock. Sand was limited except in pools. Pebble counts revealed that the median size class was 90-128mm although the dominant size was smaller. Embeddedness was determined to be relatively low, typically rated at less than 25% according to visual estimates, although some units in reach 4 were classified as having higher embeddedness.

Table 2-18. Rock Creek channel characteristics.

Characteristic	Value
Gradient	1.4%
Wetted Width	9.9 m
Bankfull Width	13.9 m
Primary Habitat	Large/small substrate riffles
Secondary Habitat	Pools

Table 2-19. Rock Creek substrate characteristics.

Characteristic	Value
Sand	3%
Gravel	28%
Cobble	59%
Boulder	10%
Bedrock	0%
Embeddedness	20%
D50	109 mm
D90	309 mm

A water temperature data logger deployed in Rock Creek was not recovered; therefore no temperature data was collected in 2004. Although temperature was not monitored, the habitat surveys revealed that riparian shade was typically adequate in the upper reaches. The primary overstory vegetation in reach 4 was mature mixed hardwoods and conifers.

Table 2-20. Rock Creek water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	NA
Date of Max 7-DAD	NA
Duration greater than 64 deg-F	NA

The B-IBI score indicated high biological integrity in Rock Creek 4. There was a single score receiving a low rating for the number of intolerant taxa, although there was a sensitive taxa present in the sample. The percent tolerant taxa score was very low at about 2%. High numbers of stonefly and mayfly species were present, indicating good water quality and habitat conditions. However, only a moderate number of caddisfly taxa were identified. The number of clinger taxa, which are often sensitive to sediment pollution, was also high.

The majority of B-IBI metric scores are centrally located in the ranges for biological ratings with the exception of the percent predator taxa, which may increase to a higher rating with slight improvement in predator numbers. Improvements to habitat complexity and lower water temperatures may increase biological diversity, specifically the number of caddisfly taxa and the number of intolerant taxa.

Table 2-21. Rock Creek macroinvertebrate community metrics from 10/14/04 survey; Figure 2-1 shows the location of the water quality station RCS050.

BIBI Metrics	Value	Score
Total number of taxa	44	high
Number of Mayfly taxa	9	high
Number of Stonefly taxa	8	high
Number of Caddisfly taxa	7	moderate
Number of long-lived taxa	7	high
Number of intolerant taxa	1	low
Percent tolerant taxa	2%	high
Percent predator taxa	16%	moderate
Number of clinger taxa	22	high
Percent dominance (three taxa)	41%	high
Total BIBI score	**42**	**high biological integrity**

Section 3 - Washougal River Watershed Summary

Conditions and Opportunities (from Lower Columbia Fish Recovery Board, Dec. 2004. Kalama, Washougal and Lewis River Habitat Assessments: Chapter 6: The Washougal River Basin)

- *Strengths*
    - Amounts of channel margin and off-channel fish rearing habitat have changed little from historic conditions.
    - The river is unregulated.
    - Riparian species composition favors conifer growth and large wood recruitment potential generally is fair to good watershed-wide. Several tributaries in the Little Washougal and West Fork Washougal Rivers and in Wildboy and Texas Creeks provide functional riparian zones.
    - Available spawning substrates have low amounts of fine sediment material and low embeddedness. Texas Creek was found to have a good amount of high quality spawning substrate.

- *Weaknesses*
    - Several weaknesses were identified in the lower Washougal River related to floodplain encroachment, incision, disconnection and bank modification/armoring.
    - 50% of the riparian stands in the Washougal River basin were determined to be sparse. Riparian canopies provide little shade in wider sections of the river and likely result in increased water temperatures.
    - Spawning gravel deposits are sparse and may be naturally supply-limited due to geologic factors.

- *Restoration Opportunities*
    - Future restoration of hydromodified habitats in the lower Washougal River should focus on preserving existing natural channel margins and areas with existing functional floodplain habitats.
    - Improvement of riparian conditions may include protecting existing riparian vegetation and promoting recovery where possible. Specifically, the Little Washougal River reaches 1C and 2B, and Boulder Creek were mentioned as areas where protections should preclude future riparian degradation. Several areas were identified as opportunities for riparian plantings or other techniques to narrow the view-to-sky values. Techniques include hardwood conversion and releasing conifers in mixed stands, and also under-planting to increase stand densities Opportunities are limited in the lower Washougal River since these reaches likely offered naturally low levels of shade and wood recruitment potential.
    - Encouraging riparian revegetation in Little Washougal reach 1 would help reduce fine sediment loading.
    - Low gradient portions of the Little Washougal and West Fork Washougal Rivers, and Boulder Creek offer good opportunities for wood placement. Wood features, or potentially even rock structures, would likely entrain sediment bedload, allowing deposition of small substrate sizes that are currently transported through the system due to lack of channel structure.

Data Summary for the Washougal River Watershed

Habitat was surveyed by R2 Resource Consultants, Inc for the majority of lower main stem Washougal River below the confluence of the Little Washougal River. Much of the main stem Little Washougal River was surveyed, and Boulder Creek was surveyed in the upper watershed. A couple of main stem upper Washougal River reaches were surveyed, as well branches on the West Fork Washougal River and Wildboy Creek (Figure 3-1).

Quite a bit of work was performed in the watershed including the deployment of seven water temperature data loggers, the collection of three macroinvertebrate samples, and the completion of six habitat surveys. Unfortunately, in only two reaches were all three activities completed. Monitoring and habitat surveys were performed throughout the Washougal River watershed using a coordinated effort between county staff, volunteers, and consultants. Forecasting the locations of habitat surveys for selecting reaches for water temperature monitoring proved to be difficult. The county's focus on smaller rivers and streams biased the selection of reaches for water quality monitoring towards the Little Washougal River watershed.

Macroinvertebrate samples were collected in three reaches in the Little Washougal River watershed on Boulder Creek and Little Washougal reaches 1 and 2B, with habitat surveys performed in each. No water temperature data was recorded in Boulder Creek.

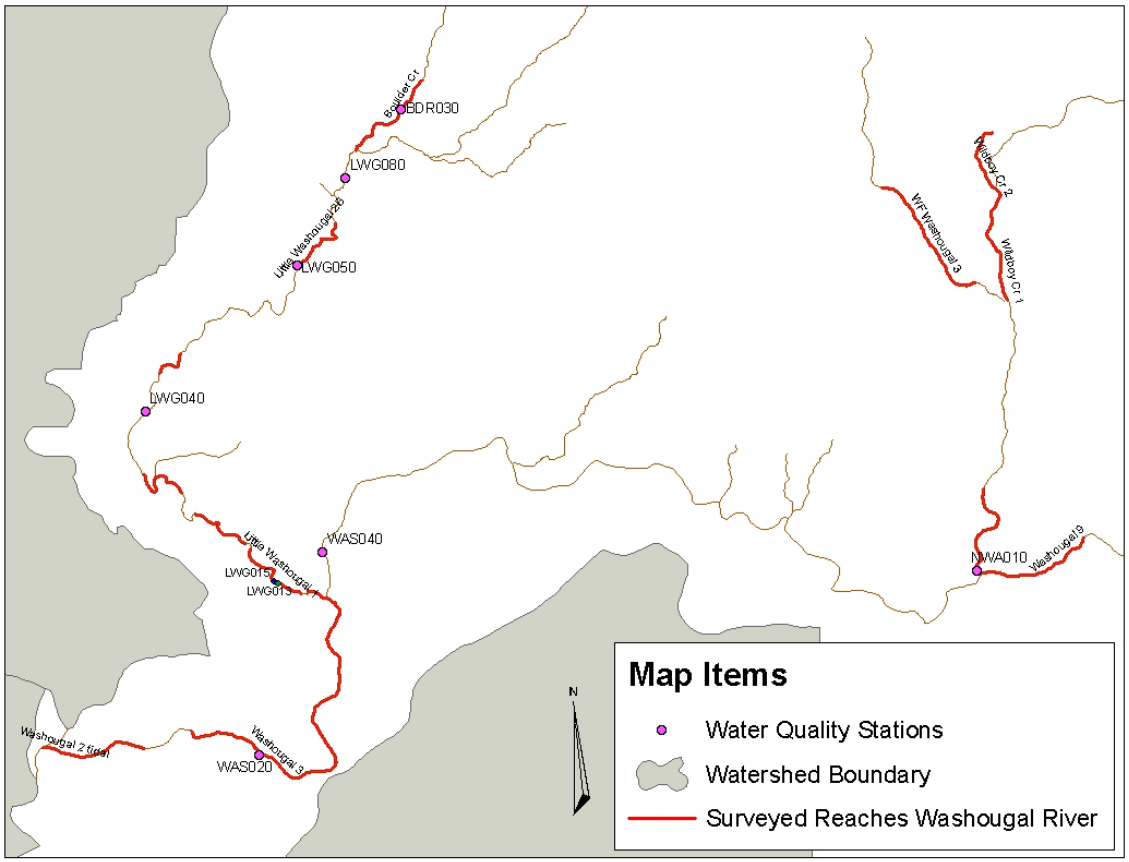

Figure 3-1. Map of the Washougal River watershed showing the reaches where habitat surveys were performed and locations of the water quality monitoring stations; macroinvertebrate samples

were collected from BDR030 in Boulder Creek, LWG015 in Little Washougal reach 1, and from LWG050 in Little Washougal reach 2B.

Water Temperature Summary

Table 3-1 summarizes the continuous water temperature data for the Washougal River watershed stations that were monitored in 2004. The summary value is the maximum of the 7-day moving average of daily maximum temperatures. The 2003 Washington State water quality standards, currently under EPA review, utilize this metric to determine temperature compliance. The duration greater than 64 deg-F indicates the number of days on which the *daily* maximum temperature exceeded the 64° F criterion. Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent out of compliance is also of interest.

High water temperatures were observed throughout much of the lower main stem Washougal and Little Washougal River reaches (Table 3-1; Figures 3-2 and 3-3). Water temperatures were higher than the target criteria at all stations, however, values were near the target criteria in the upper reaches and tributaries of the Little Washougal River and the West Fork Washougal River.

Elevated temperature data relates to sparse riparian vegetation that would provide shade to the stream channel, particularly in the lower reaches of the Washougal River and its major tributaries. In general, much of the area over the river channel was open to the sky. Higher amounts of forest cover in the upper tributaries should result in lower water temperatures relative to the lower tributaries, although values may still be at levels that are harmful to aquatic life.

Table 3-1. Washougal River water temperature data summary, summer 2004; the reaches are roughly ordered from upstream to downstream.

EDT Reach Name	Date	7-DAD Max Temperature	Duration > 64 deg-F
Washougal 3	8/13/04	76.4	59
Washougal 4	7/26/04	74.6	57
Little Washougal 1	8/12/04	73.2	54
Little Washougal 1C	8/12/04	69.7	42
Little Washougal 2B	8/12/04	67.9	37
Little Washougal 2D	8/12/04	65.9	20
WF Washougal 1	8/12/04	68.4	39

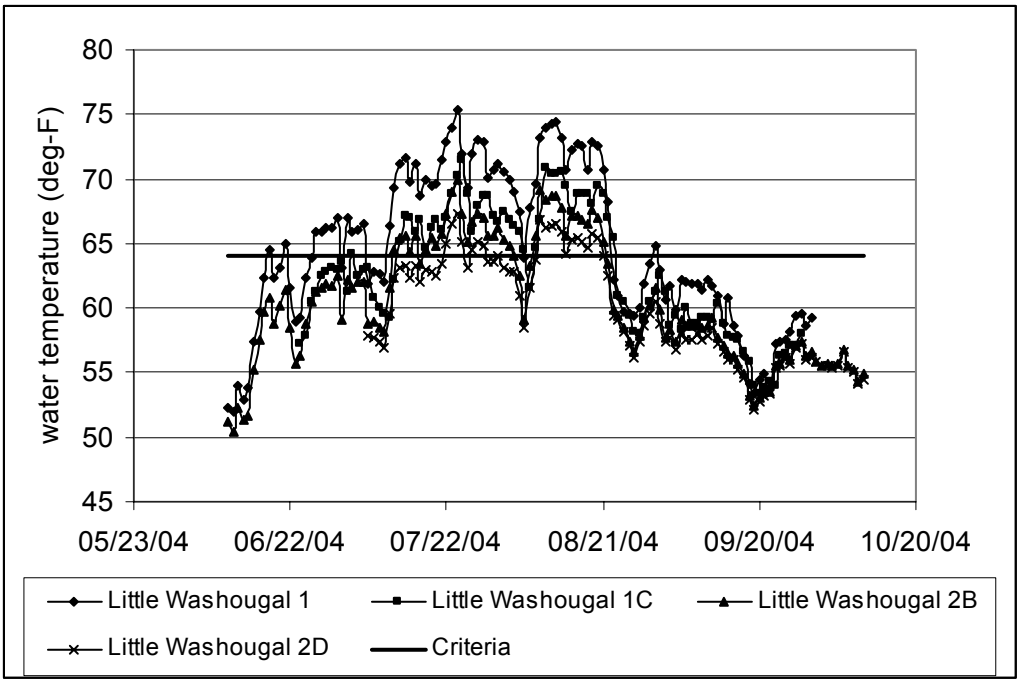

Figure 3-2. Little Washougal River water temperatures, as depicted by the 7-DADMax value, measured in 2004; a criterion shown is the 64-deg F target.

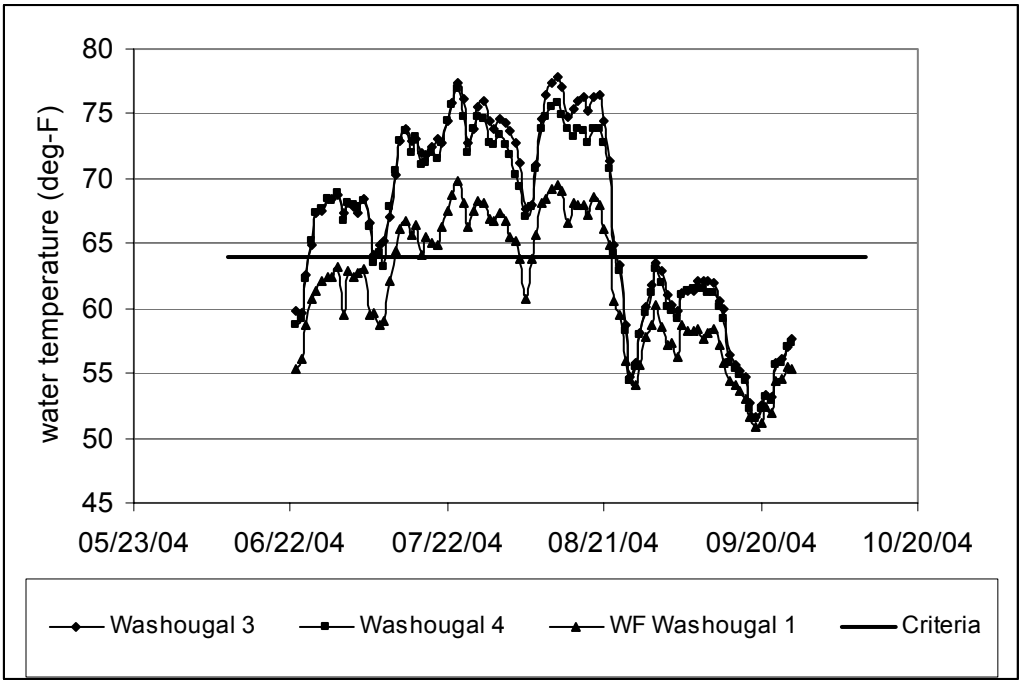

Figure 3-3. Lower Washougal River and West Fork Washougal River water temperatures, as depicted by the 7-DADMax value, measured in 2004; a criterion shown is the 64-deg F target.

Biological Survey Summary

Water Resources utilizes the widely applied Benthic Macroinvertebrate Index of Biological Integrity, or B-IBI (Karr, 1998), to measure the health of streams based on the macroinvertebrate population.

Karr's B-IBI is based on ten metrics that describe various aspects of stream biology, including tolerance and intolerance to pollution, taxonomic richness, feeding ecology, reproductive strategy, and population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species are often the most sensitive to disruption and will be the first to disappear from a stream as human disturbance increases.

The raw data value for each metric are converted to a score of 1, 3, or 5, and the ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10-24 indicate low biological integrity, from 25-39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

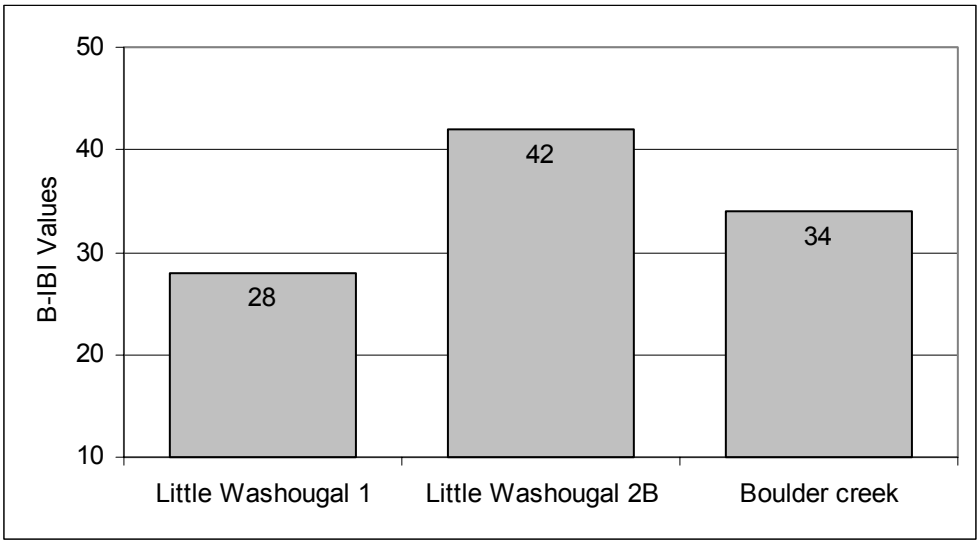

Figure 3-4.Little Washougal River B-IBI scores in 2004. Scores indicated moderate-to-high biological integrity at the sites sampled.

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score. Sub-index scores are broken down in the individual reach summaries in the following pages. Appendix A provides a basic description of each B-IBI metric and the expected response to stream and watershed degradation.

Macroinvertebrate sampling is usually conducted on riffle habitat within a portion of a single reach; consequently results may not be indicative of the entire stream. However, the cumulative result of upstream land use and management has an impact on conditions at the sampling station. The moderate to high biological integrity indicated by samples from the Little Washougal River suggests that human influence on water quality and habitat is assessable. Many of the metrics in the B-IBI are influenced by factors that may be naturally deficient in the watershed, for example, a limitation in gravel and cobble deposits due to naturally limited sediment supply. The high integrity rating in the middle section of the river, specifically in Little Washougal reach 2B, is

encouraging and supports recommendations in the habitat report to protect and enhance this high quality area. The B-IBI scores reflect impacts to habitat complexity and stability. Based on metric scores and our existing knowledge of water quality conditions, the impacts to benthic macroinvertebrate populations are attributable largely to altered flow regimes and sediment accumulation. Elevated stream temperatures are a known problem and may also be impacting some of the more sensitive taxa.

Washougal River
Little Washougal River Reach 1

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Little Washougal (Lower))

Area: 10.2 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate, 15.2% average watershed slope
Stream Size: large, 5th order stream
Development: 4.8 acre median parcel size; 13.4% total impervious area; primarily forest and agriculture with low-density residential development
Forest Cover: 48.2% forest land cover

Reach Notes

EDT Tier: 2
Ecoregion: Level 4 Ecoregion 3d Willamette Valley Foothills.
Elevation: 100 feet

Little Washougal River reach 1 is the lower-most 2.5 miles of the Little Washougal River, a primary tributary to the lower main stem Washougal River. The lower half-mile of the reach flows through a narrow bedrock-controlled canyon. Bedforms in the canyon consist of step pool to pool riffle sequences controlled by bedrock. Above the canyon, the river flows through a valley with relatively gentle side slopes. Here the river is alluvial to semi alluvial in nature, with abundant in-channel gravel and cobble deposits. Overall the reach has a moderate gradient of 1.1%. The channel was classified as a moderate gradient contained, to moderate gradient mixed control type, consisting of mainly pool-riffle sequences. The channel is likely responsive to large wood, which is related to pool depth and spacing and also contributes to sediment storage.

Table 3-2. Little Washougal 1 channel characteristics.

Characteristic	Value
Gradient	1.1%
Wetted Width	11.2 m
Bankfull Width	13.2 m
Primary Habitat	Pool
Secondary Habitat	Large cobble/boulder riffle

Table 3-3. Little Washougal 1 substrate characteristics.

Characteristic	Value
Sand	18%
Gravel	34%
Cobble	28%
Boulder	11%
Bedrock	9%
Embeddedness	39%
D50	54 mm
D90	120 mm

Water temperature in the lower Little Washougal River was very high in 2004, nearly 10 deg-F higher than the target criteria of 64 deg-F (Table 3-4). Monitoring revealed a similar maximum water temperature in 2003, with a Max 7-DAD value of 73.6 deg-F recorded on 7/21/03. The riparian assessment for the lower Little Washougal River found that riparian cover was good in the canyon section, but that many areas in the unconfined valley that have been cleared for residential development or agriculture left a wide zone without vegetative cover near the stream. Maximum daily water temperatures were above target levels for over 50 days, from roughly mid-July to late-August.

Table 3-4. Little Washougal 1 water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	73.2 deg-F
Date of Max 7-DAD	8/12/04
Duration greater than 64 deg-F	54

The B-IBI score indicated moderate biological integrity in Little Washougal reach 1. Low scores for several of the sub-indices indicated impacts to some of the most sensitive species in the macroinvertebrate community. No intolerant species were observed in the sample. In addition, the number of predators and the number of different caddisfly species were low. The section of the reach that was surveyed had sparse deposits of substrate overlaying large bedrock features. Habitat availability likely influenced the richness and composition metrics. Tolerance metrics indicated that the most pollution sensitive species were absent, but that the community also did not have a very large percentage of pollution tolerant species.

One or two sub-index scores were near the upper end of the ranges and may improve biological ratings with marginal increases in habitat conditions. An example includes the percent dominance index, which was very near the high rating. Improvements to habitat complexity and decreasing water temperatures will help increase biological diversity.

The habitat survey report identifies a transition from a bedrock canyon to a more alluvial channel within this reach. The macroinvertebrate sample was collected in the transition area. Macroinvertebrate populations are likely different for the two channel types and a sample collected slightly upstream may be more representative of the majority of the reach.

Previous macroinvertebrate samples collected at this station by Clark County in 2002 and 2003 also indicated low to moderate biological integrity.

Table 3-5. Little Washougal 1 macroinvertebrate community metrics from 10/03/04 survey; Figure 3-1 shows the location of the water quality station LWG015.

BIBI Metrics	Value	Score
Total number of taxa	34	moderate
Number of Mayfly taxa	6	moderate
Number of Stonefly taxa	6	moderate
Number of Caddisfly taxa	4	low
Number of long-lived taxa	5	high
Number of intolerant taxa	0	low
Percent tolerant taxa	14%	high
Percent predator taxa	7%	low
Number of clinger taxa	16	moderate
Percent dominance (three taxa)	52%	moderate
Total BIBI score	**28**	**moderate biological integrity**

Washougal River
Little Washougal River Reach 2B

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Little Washougal (Lower))

Area: 10.2 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate, 15.2% average watershed slope
Stream Size: large, 5th order stream
Development: 4.8 acre median parcel size; 13.4% total impervious area; primarily forest and agriculture with low-density residential development
Forest Cover: 48.2% forest land cover

Reach Notes

EDT Tier: 2
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 500 feet

Little Washougal River reach 2B is located near the upper end of the lower Little Washougal subwatershed. The reach ends near a private bridge at 40th Circle off of Stauffer Road and extends upstream nearly a mile to the confluence with a small unnamed tributary entering on the right bank. The river flows through a gently sloping v-shaped valley and has moderate to low confinement. Little Washougal reach 2B has a gradient of about 2% and the channel is a moderate gradient, mixed control type. Bedforms consist of forced pool rifle sequences when wood is abundant and the channel is considered semi-alluvial. The channel is likely responsive to flow obstruction, including wood and rocks.

Table 3-6. Little Washougal 2B channel characteristics.

Characteristic	Value
Gradient	2.0%
Wetted Width	10.9 m
Bankfull Width	13.4 m
Primary Habitat	Small cobble/gravel riffle
Secondary Habitat	Pools

Table 3-7. Little Washougal 2B substrate characteristics.

Characteristic	Value
Sand	17%
Gravel	24%
Cobble	28%
Boulder	21%
Bedrock	10%
Embeddedness	35%
D50	67 mm
D90	147 mm

Water temperature in 2004 was above the target criteria of 64 deg-F for nearly 40 days, although the magnitude of exceedances is much lower than observed downstream. Reach 2B has relatively good riparian conditions, although areas where the valley is less confined have been cleared for residential development and timber harvest. Riparian stands are either conifer or mixed along both banks and the view to sky is low relative to the lower river.

Table 3-8. Little Washougal 2B water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	67.9
Date of Max 7-DAD	8/12/04
Duration greater than 64 deg-F	37

The B-IBI score indicated high biological integrity in Little Washougal reach 2B. There were no scores receiving low ratings and only a few earned moderate ratings. Several pollution intolerant species were observed in the sample. A number of mayfly and stonefly species were present indicating good water quality and habitat conditions. Habitat availability may influence some richness and composition metrics, particularly the number of caddisfly taxa. The macroinvertebrate community did not have a high percentage of pollution tolerant species.

One or two sub-index scores were near the upper end of the ranges and may improve biological ratings with marginal increases in habitat conditions. Examples include the total number of taxa and number of clinger taxa, which scored near the high rating. Improvements to habitat complexity and decreasing water temperatures will help increase biological diversity.

Table 3-9. Little Washougal 2B macroinvertebrate community metrics from 10/15/04 survey; Figure 3-1 shows the location of the water quality station LWG050.

BIBI Metrics	Value	Score
Total number of taxa	38	moderate
Number of Mayfly taxa	10	high
Number of Stonefly taxa	8	high
Number of Caddisfly taxa	7	moderate
Number of long-lived taxa	5	high
Number of intolerant taxa	6	high
Percent tolerant taxa	8%	high
Percent predator taxa	11%	moderate
Number of clinger taxa	20	moderate
Percent dominance (three taxa)	38%	high
Total BIBI score	**42**	**high biological integrity**

Washougal River
Boulder Creek 1

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Boulder Creek)

Area: 7.3 square miles
Hydrogeology: older rock/bedrock
Topography: moderate to steep, 25.4% average watershed slope
Stream Size: small, 4th order stream
Development: 5.2 acre median parcel size; 6.8% total impervious area; primarily timber-managed forest with some low-density residential development
Forest Cover: 80.2% forest land cover

Reach Notes

EDT Tier: 3
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys.
Elevation: 680 feet

Boulder Creek reach 1 is located in the upper Little Washougal watershed. The reach extends from the creek's confluence with the East Fork Little Washougal River upstream about one mile to the Boulder Creek road crossing. Boulder Creek reach 1 flows through a narrow v-shaped valley and generally has a moderate confinement level. The channel is classified as a moderate gradient, mixed control type with a slope of about 3%. Bedforms naturally consist of forced pool riffle sequences with abundant wood, to plane-bed when large wood is scarce. Boulder Creek would be expected to be highly responsive to large wood and log jams, which are important for pool formation and sediment storage.

Table 3-10. Boulder Creek channel characteristics.

Characteristic	Value
Gradient	3.0%
Wetted Width	6.9 m
Bankfull Width	8.1 m
Primary Habitat	Small cobble/gravel riffle
Secondary Habitat	Pools

Table 3-11. Boulder Creek substrate characteristics.

Characteristic	Value
Sand	10%
Gravel	20%
Cobble	39%
Boulder	29%
Bedrock	1%
Embeddedness	24%
D50	80 mm
D90	209 mm

Although no water temperature data was recorded in this reach during 2004, a maximum value of 65.9 deg-F was observed on 8/12/04 at a site located downstream of Boulder Creek on the main stem Little Washougal River (LWG080). Boulder Creek should have similar water temperature, however, may be slightly warmer due to more open canopy and the fact that the other tributaries influencing the downstream station, such as the East Fork Little Washougal River and Jones Creek, are typically cold. Boulder Creek flows through a generally undisturbed valley except for adjacent timber harvest activities. Low density residential use on the western slope of the watershed is on the rise. Riparian measurements indicated a relatively closed canopy over the channel providing shade to the stream.

Table 3-12. Boulder Creek water temperature measurements.

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	Not measured
Date of Max 7-DAD	Not measured
Duration greater than 64 deg-F	Not measured

The B-IBI score indicated moderate biological integrity in Boulder Creek reach 1 (Table 3-13). Both the number of intolerant taxa and the percent predator taxa sub-indices received low ratings. A number of mayfly and stonefly species were present indicating good water quality and habitat conditions. The macroinvertebrate community did not have a high percentage of pollution tolerant species, nor was it dominated by relatively few taxa.

Five sub-index scores were literally at the upper end of the scoring ranges, including the total number of taxa, number of stonefly taxa, number of clinger taxa, number of intolerant taxa, and percent predator individuals. These scores near the threshold of high biological integrity may be an early warning of deterioration in water quality and/or habitat conditions. They also, however, indicate the potential for higher biological integrity and should improve with marginal increases in habitat conditions.

Table 3-13. Boulder Creek macroinvertebrate community metrics from 10/11/04 survey; Figure 3-1 shows the location of the water quality station BDR030.

BIBI Metrics	Value	Score
Total number of taxa	40	moderate
Number of Mayfly taxa	9	high
Number of Stonefly taxa	7	moderate
Number of Caddisfly taxa	8	moderate
Number of long-lived taxa	6	high
Number of intolerant taxa	2	low
Percent tolerant taxa	16%	high
Percent predator taxa	10%	low
Number of clinger taxa	20	moderate
Percent dominance (three taxa)	50%	high
Total BIBI score	**34**	**moderate biological integrity**

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Section 4 - Salmon Creek Watershed Summary

Conditions and Opportunities (from Lower Columbia Fish Recovery Board, Dec. 2004. Kalama, Washougal and Lewis River Habitat Assessments: Chapter 6: The Salmon Creek Basin)

- *Strengths*
    - Except for the lower river reaches, in-channel large woody debris (LW) was common-to-abundant in surveyed reaches.
    - Large amounts of lands in the lower reaches (west of I-5) are under public ownership.
- *Weaknesses*
    - More than half of the reaches assessed had poor riparian conditions for LW recruitment potential. The poor LW potential was related to high proportion of deciduous trees, sparse stand densities, and small tree sizes. Riparian conditions throughout the basin are not providing sufficient shade and are predicted to result in exceedances of state water temperature standards.
    - Riparian encroachment associated with urbanization and clear-cut timber has impacted LW potential.
    - Although the primary fish cover in Salmon Creek was depth, there were very few deep holding pools found in surveyed reaches. In tributaries, the primary fish cover was provided by overhanging vegetation from banks.
    - Embeddedness was high in all streams surveyed. The highly erodibile parent geology of the Salmon Creek basin and predominance of sandy Missoula Flood deposits give rise to higher levels of sand and embeddedness watershed wide.

- *Restoration Opportunities*
    - Riparian stands can be preserved to preclude future riparian degradation in Salmon Creek tributaries.
    - Riparian condition can be enhanced by converting deciduous stands or releasing conifers in mixed stands for enhanced growth rates. Many reaches have specific opportunities for riparian plantings or other techniques to increase shading and LW recruitment potential. Riparian planting opportunities should be evaluated for feasibility in the lower river reaches, such as Salmon reaches 1-10 and along Lake River.
    - Low gradient portions of all tributary reaches offer good opportunities for further in-channel wood placement for increasing channel complexity and habitat as well as retaining sediment.

Data Summary for the Salmon Creek Watershed

A relatively low proportion of habitat was surveyed in Salmon Creek due to the fact that fewer high-level EDT reaches were available to meet the designated sampling scheme (LCFRB, 2004). R2 Resource Consultants, Inc. surveyed Rock Creek and two mainstem Salmon Creek reaches in the upper watershed; additionally Weaver Creek and a mainstem Salmon Creek reach were surveyed, along with Lake River, in the lower watershed. Complete water quality surveys coincided with habitat surveys on Rock and Weaver Creeks. A water temperature data logger was not deployed in Salmon Creek reach 32, but a macroinvertebrate sample was collected subsequent to the habitat survey.

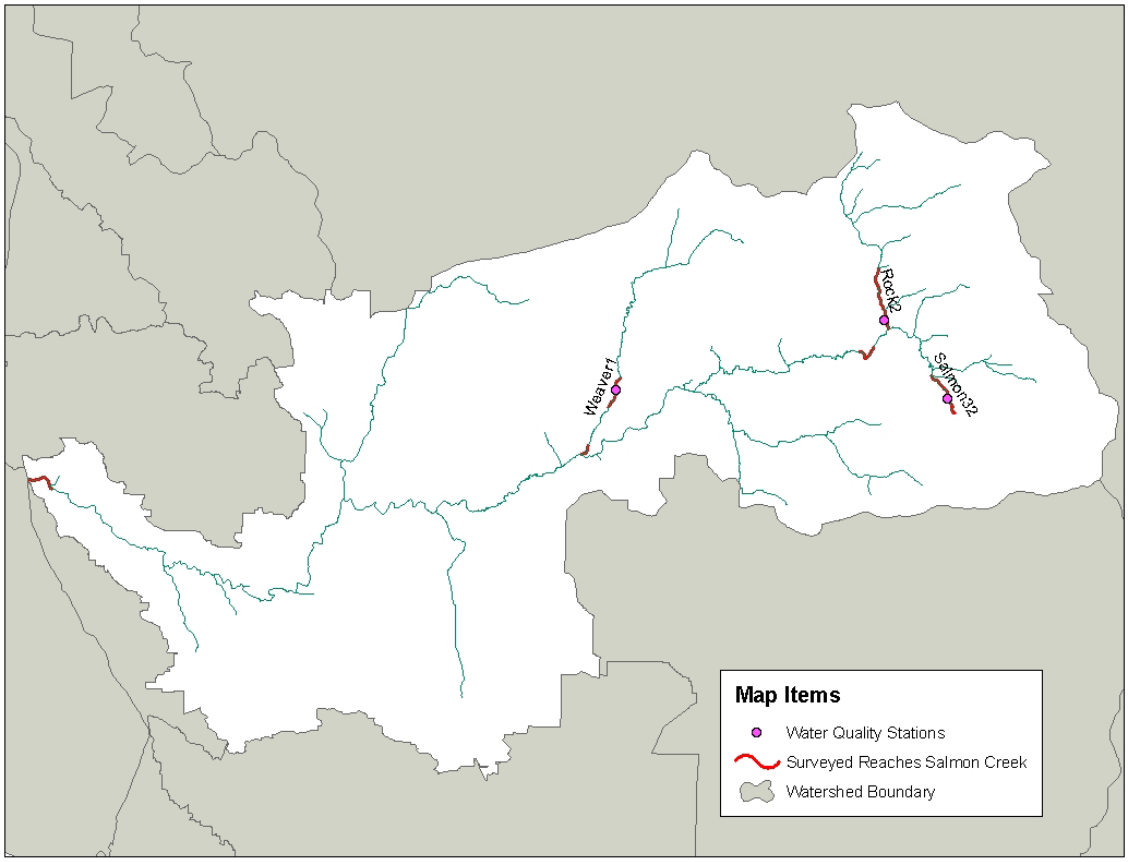

Figure 4-1. Map of the Salmon Creek watershed showing the reaches where habitat surveys were performed and locations of the water quality monitoring stations; macroinvertebrate samples were collected from the following stations: WDN010, ROC010, SMN085.

Water Temperature Summary

Table 4-1 summarizes the continuous water temperature data for the Salmon Creek watershed sites monitored in 2004. The summary value is the maximum of the 7-day moving average of daily maximum temperatures. The 2003 Washington State water quality standards, currently under EPA review, utilize this metric to determine temperature compliance. The duration greater than 64 deg-F indicates the number of days on which the *daily* maximum temperature exceeded

the 64° F criterion. Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent out of compliance is also of interest.

High water temperatures were observed at both sites monitored in 2004 (Table 4-1; Figure 4-2). Watershed-wide weaknesses that were identified in the habitat surveys included sparse, and sometimes absent, riparian vegetation providing little shade to the stream channel. Higher amounts of forest cover in the upper tributaries should result in lower water temperatures relative to the lower tributaries, although values may still be at levels that are harmful to aquatic life.

In a 2003 field investigation, Clark County found that water temperatures were higher, and the problem of elevated temperatures more widespread, than previously understood in the watershed (Schnabel, 2004). In particular, the report identified Rock Creek and Weaver Creek as two of the three warmest tributaries to Salmon Creek. The report identified the presence of ponds and a lack of riparian vegetation as principal contributing factors to high water temperatures.

Table 4-1. Salmon Creek water temperature data summary, summer 2004.

EDT Reach Name	Date	7-DAD Max Temperature	Duration > 64 deg-F
Rock Creek 1	7/24/04	72.2 deg-F	25 days
Salmon Creek 32	Not measured	Not measured	Not measured
Weaver Creek 1	7/25/04	75.5 deg-F	78 days

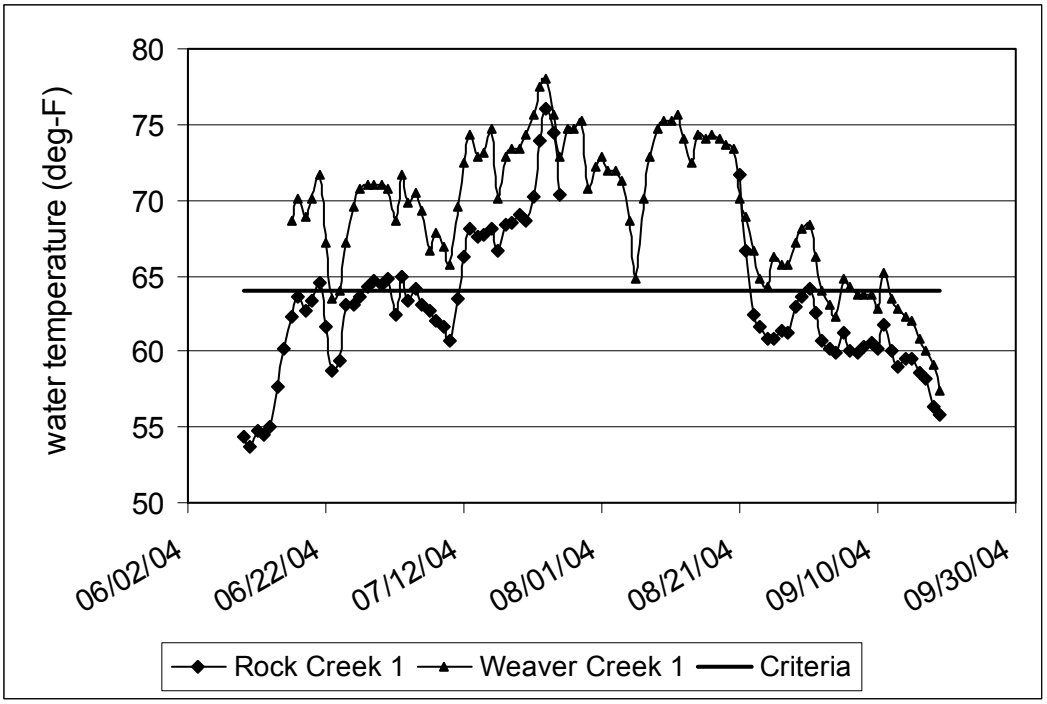

Figure 4-2. Salmon Creek water temperatures, as depicted by the 7-DADMax value, measured in 2004; a criterion shown is the 64-deg F target. The gap in the Rock Creek 1 record is due to the editing of anomalous readings.

Biological Survey Summary

Water Resources utilizes the widely applied Benthic Macroinvertebrate Index of Biological Integrity, or B-IBI (Karr, 1998), to measure the health of streams based on the macroinvertebrate population.

Karr's B-IBI is based on ten metrics that describe various aspects of stream biology, including tolerance and intolerance to pollution, taxonomic richness, feeding ecology, reproductive strategy, and population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species are often the most sensitive to disruption and will be the first to disappear from a stream as human disturbance increases.

The raw data value for each metric are converted to a score of 1, 3, or 5, and the ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10-24 indicate low biological integrity, from 25-39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

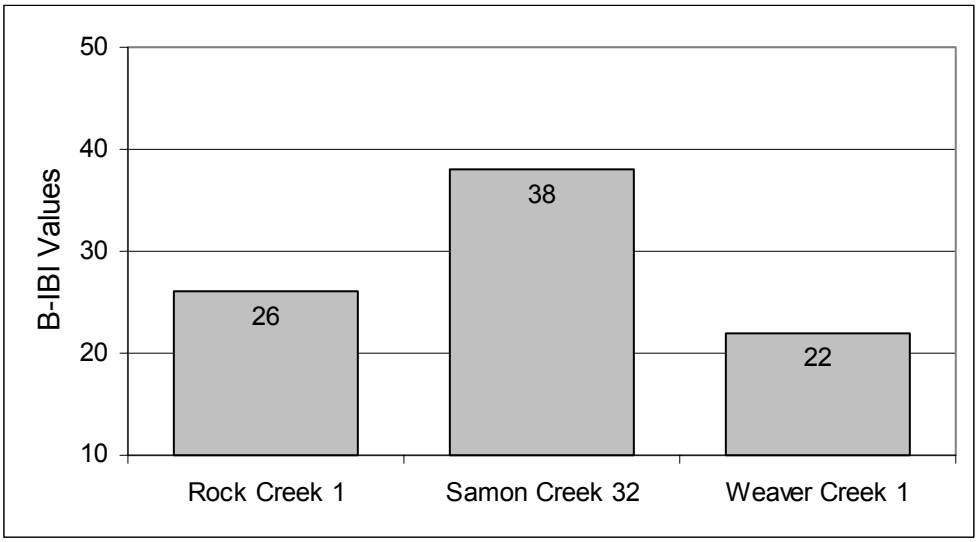

Figure 4-3. Salmon Creek B-IBI scores in 2004. Scores indicate low-to-moderate biological integrity at the sites sampled.

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score. Sub-index scores are broken down in the individual reach summaries in the following pages. Appendix A provides a basic description of each B-IBI metric and the expected response to stream and watershed degradation.

Macroinvertebrate sampling is usually conducted on riffle habitat within a portion of a single reach; consequently results may not be indicative of the entire stream. However, the cumulative result of upstream land use and management has an impact on conditions at the sampling station. The low to moderate biological integrity indicated by samples from Salmon Creek suggests that human influence on Salmon Creek has been substantial. The B-IBI scores reflect impacts to habitat complexity and stability. Based on metric scores and our existing knowledge of water quality conditions, the impacts to benthic macroinvertebrate populations are attributable largely to

altered flow regimes and sediment accumulation. Elevated stream temperatures are a known problem and may also be impacting some of the more sensitive taxa.

Salmon Creek
Rock Creek 1

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Rock Creek)

Area: 7.7 square miles
Hydrogeology: mostly older rock/bedrock with some Troutdale gravel
Topography: moderate, 17% average watershed slope
Stream Size: small, 3rd order stream
Development: 2.7 acre median parcel size; 10% total impervious area; primarily forest and agriculture
Forest Cover: 60% forest land cover

Reach Notes

EDT Tier: 3
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys
Elevation: 355 feet

Rock Creek is a tributary to Salmon Creek that enters at about river mile 22 (RM22), near its intersection with Risto Road in the Venorsborg area. The lower 1,500 feet of the creek, delineated as reach Rock Creek 1, has a gradient of about 1% and flows through a narrow v-shaped valley to its confluence with Salmon Creek. The channel was classified as a moderate gradient, moderate control channel type, primarily consisting of forced pool-riffle sequences with gravel stored in and around large wood features.

Table 4-2. Rock Creek 1 channel characteristics.

Characteristic	Value
Gradient	1%
Wetted Width	2.0 m
Bankfull Width	7.1 m
Primary Habitat	Pools
Secondary Habitat	Large cobble/boulder riffles

Table 4-3. Rock Creek 1 substrate characteristics.

Characteristic	Value
Sand	29%
Gravel	54%
Cobble	5%
Boulder	5%
Bedrock	6%
Embeddedness	31%
D50	NA
D90	NA

Maximum observed stream temperature in Rock Creek reach 1 exceeded the state criterion by over 8 degrees in 2004 (Table 4-4 below). The duration of exceedance was relatively short but

this was due to the fact that a large portion of the record, including most of August, was removed for recurring anomalous spikes in the record. It appeared the data logger was exposed to the air for a few hours each day, possibly a result of the stream level being routinely lowered due to withdrawal or diversion. The maximum water temperature was higher in 2004 compared to the maximum value of 70.1 deg-F observed at the station on 7/20/03. Field crews noted a preponderance of beaver ponds in the surveyed reaches, which may make worse already elevated water temperatures.

Table 4-4. Rock Creek 1 water temperature measurements

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	72.2 deg-F
Date of Max 7-DAD	7/24/2004
Duration greater than 64 deg-F	25 days*

*Note: See text above qualifying this measurement.

The B-IBI score indicated moderate biological integrity in Rock Creek reach 1. Low scores for several of the sub-indices indicated impacts to some of the most sensitive species represented in the macroinvertebrate community. Very few intolerant species were observed in the sample. In addition, the number of predators and the number of different stonefly species were low. These categories typically score low in moderately impacted streams, especially those with elevated water temperatures and high substrate embeddedness.

Several sub-index scores were near the upper end of the ranges and may significantly improve biological ratings with marginal increases in habitat conditions. Examples include the number of mayfly and clinger taxa, both of which would have been scored higher with the presence of one or two more taxa. Also the percent dominance of the sample's three primary species was only slightly above the 50% target. Improvements to habitat complexity and decreasing water temperatures will help increase biological diversity.

Table 4-5. Rock Creek 1 macroinvertebrate community metrics from 10/22/04 survey; Figure 4-1 shows the location of the water quality station ROC010.

BIBI Metrics	Value	Score
Total number of taxa	36	moderate
Number of Mayfly taxa	7	moderate
Number of Stonefly taxa	3	low
Number of Caddisfly taxa	7	moderate
Number of long-lived taxa	8	high
Number of intolerant taxa	1	low
Percent tolerant taxa	34%	moderate
Percent predator taxa	5%	low
Number of clinger taxa	19	moderate
Percent dominance (three taxa)	55%	moderate
Total BIBI score	**26**	**moderate biological integrity**

Salmon Creek
Upper Salmon Creek 32

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Salmon Creek (R.M. 22.20))

Area: 10.8 square miles
Hydrogeology: older rock/bedrock
Topography: moderate, 21% average watershed slope
Stream Size: small, 3rd order stream
Development: 3.0 acre median parcel size; 10% total impervious area; primarily forest with some agriculture and low density residential
Forest Cover: 68% forest land cover

Reach Notes

EDT Tier: 3
Ecoregion: Level 4 Ecoregion 4a Western Cascades Lowlands and Valleys
Elevation: 440 feet

Salmon Creek reach 32 is located in upper Salmon Creek, running from about the mouth of Little Salmon Creek to the base of Salmon Falls. This upper stretch is the most upstream reach of the river that is accessible to anadromous fish. The 2.5-mile long reach is fairly steep, having a gradient of 4.5%, and flows through a narrow v-shaped valley to its confluence with a small tributary near 199th Street. The channel is controlled by bedrock and was classified as an incised foot slope channel. Large wood was abundant in the reach and was the primary fish cover type. Large wood plays an important role in sediment storage and pool formation, and medium-sized (20-50 cm) pieces of wood were relatively common in the stream channel. Some root-wads, but no debris jams, were observed in the survey.

Table 4-6. Salmon Creek 32 channel characteristics.

Characteristic	Value
Gradient	4.5%
Wetted Width	3.0 m
Bankfull Width	5.6 m
Primary Habitat	Large cobble/boulder riffles
Secondary Habitat	Pools

Table 4-7. Salmon Creek 32 substrate characteristics.

Characteristic	Value
Sand	38%
Gravel	47%
Cobble	11%
Boulder	3%
Bedrock	1%
Embeddedness	57%
D50	NA
D90	NA

Although no water temperature data was recorded in this reach during 2004, a maximum value of 67.2 deg-F was observed on 7/29/03 at a site located about a mile and a half downstream of Salmon Creek reach 32, in Salmon Creek reach 28. It is reasonable to expect Salmon Creek reach 32 to nearly meet target water temperatures.

While very near the high biological integrity category, the B-IBI score indicated only moderate biological integrity in Salmon Creek reach 32. Only the number of intolerant taxa and the number of predator taxa sub-indices scored in the low category. Substrate embeddedness was relatively high in this reach, which may limit diversity of predator species. Both the stonefly and mayfly species richness categories scored in the upper end of the moderate ranges and could add to the overall score with habitat improvements.

Table 4-8. Salmon Creek 32 macroinvertebrate community metrics from 10/21/04 survey; Figure 4-1 shows the location of the water quality station SMN085.

BIBI Metrics	Value	Score
Total number of taxa	44	high
Number of Mayfly taxa	7	moderate
Number of Stonefly taxa	7	moderate
Number of Caddisfly taxa	10	high
Number of long-lived taxa	9	high
Number of intolerant taxa	2	low
Percent tolerant taxa	17%	High
Percent predator taxa	9%	low
Number of clinger taxa	28	high
Percent dominance (three taxa)	42%	high
Total BIBI score	**38**	**moderate biological integrity**

Salmon Creek
Weaver Creek 1

It is important to first look at the natural and developed characteristics of the drainage area that affect the characteristics of the streams being monitored. Not all monitoring stations were located in the downstream reaches of subwatersheds so the characteristics in the list below are not specific to the station's contributing area:

Subwatershed Characteristics (Woodin Creek)

Area: 7.7 square miles
Hydrogeology: mix of unconsolidated sedimentary rock/deposits and Troutdale gravel
Topography: low to moderate, 6.2% average watershed slope
Stream Size: small, 2nd order stream
Development: 0.3 acre median parcel size; 24% total impervious area; primarily agriculture and low density residential with some forest in the upper watershed
Forest Cover: 31.8% forest land cover

Reach Notes

EDT Tier: 4
Ecoregion: Level 4 Ecoregion 3a Portland/Vancouver Basin
Elevation: 230

Weaver Creek, also known locally as Woodin Creek, runs tributary to Salmon Creek at about RM15, just upstream of the State Route 503 bridge. The Weaver Creek reach 1 extends from the mouth upstream to about the 199th Street crossing near Battle Ground. The 2-mile long reach has a gradient of about 1% and flows through a narrow v-shaped valley to a small alluvial fan in the Salmon Creek floodplain. The channel is controlled by bedrock and was classified as moderate gradient, mixed control to moderate gradient, contained channel type. Deep pools were generally lacking, however the frequency of beaver ponds was high. Channel cross-section depths were generally shallow in the free-flowing sections. There was a high potential for an increased thermal regime.

Table 4-9. Weaver Creek 1 channel characteristics.

Characteristic	Value
Gradient	1%
Wetted Width	3.4 m
Bankfull Width	3.6 m
Primary Habitat	Pools
Secondary Habitat	Small cobble/gravel riffles

Table 4-10. Weaver Creek 1 substrate characteristics.

Characteristic	Value
Sand	33%
Gravel	49%
Cobble	16%
Boulder	1%
Bedrock	2%
Embeddedness	51%
D50	NA
D90	NA

Weaver Creek was very warm, over 10 degrees higher than the criteria for nearly three months in 2004 (Table 4-11 below). The maximum water temperature was higher in 2004 compared to the maximum value of 70.8 deg-F observed at the site on 7/21/03.

Table 4-11. Weaver Creek 1 water temperature measurements

Characteristic	Value
Maximum 7-day moving average of the daily maximum water temperature (Max 7-DAD)	75.5 deg-F
Date of Max 7-DAD	7/25/2004
Duration greater than 64 deg-F	78 days

The B-IBI score indicated low biological integrity in Weaver Creek reach 1. No intolerant or stonefly taxa were observed in the sample and low numbers of mayfly and caddisfly taxa were noted. Predator species were almost absent. Furthermore, the percent dominance sub-index very nearly scored in the low category as well. The most common type of insect in the sample was an aquatic worm species. A measure of pollution from organic enrichment, known as the Hilsenhof Biotic Index, scored very high for the Weaver Creek sample. The scores indicate severe negative impact of land use activities to water quality and habitat degradation in this water body.

Table 4-12. Weaver Creek 1 macroinvertebrate community metrics from 10/25/04 survey; Figure 4-1 shows the location of the water quality station WDN030.

BIBI Metrics	Value	Score
Total number of taxa	29	moderate
Number of Mayfly taxa	3	low
Number of Stonefly taxa	0	low
Number of Caddisfly taxa	4	low
Number of long-lived taxa	5	high
Number of intolerant taxa	0	low
Percent tolerant taxa	23%	moderate
Percent predator taxa	4%	low
Number of clinger taxa	12	moderate
Percent dominance (three taxa)	75%	moderate
Total BIBI score	**22**	**low biological integrity**

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Appendix A. Benthic-Macroinvertebrate Index of Biological Integrity Description

The following are descriptions of individual BIBI sub-metrics. For a full description see the King County website http://dnr.metrokc.gov/wlr/waterres/Bugs/metrics_desc.htm.

Total taxa richness: The total number of taxa collected. Stream biodiversity declines as flow regimes are altered, habitat is lost, chemicals are introduced, energy cycles are disrupted, and alien taxa invade.

Mayfly (Ephemeroptera) taxa richness: The total number of mayfly species collected. Mayfly diversity declines in response to human influence. Many graze on algae. They are sensitive to chemical pollution that interferes with algae growth, but may increase in diversity over stoneflies and caddisflies in cases of high nutrient enrichment.

Stonefly (Plecoptera) taxa richness: The total number of stonefly species collected. Stoneflies are the first to disappear as human disturbance increases. Many are predators that depend on hiding between rocks- these types are very sensitive to sediment pollution. Others are shredders that rely on leaf litter from overhead tree canopies. Most require cool water and high dissolved oxygen levels.

Caddisfly (Trichoptera) taxa richness: The total number of caddisfly species collected. Caddisflies are a diverse group including some sensitive and some tolerant taxa representing many functional feeding groups (scrapers, collectors, predators). Taxa richness tends to decline as stream habitat becomes less varied and complex.

Intolerant taxa richness: These are the most sensitive taxa, representing approximately 5-10% of the taxa present in a region. They are the first to disappear as disturbance increases.

Clinger taxa richness: These taxa are adapted to hold onto smooth substrates in fast water. Because they occupy the open area between rocks, they are particularly sensitive to fine sediment.

Long-lived taxa: These taxa require more than one year to complete their life cycles, thus they are exposed to all the human activities that might influence the stream over a lengthy period. These taxa may disappear from streams that run dry during part of the year or experience on-going cyclical problems that interfere with their life cycles.

Percent tolerant: Tolerant taxa are present at most stream sites, but as disturbance increases they will represent an increasingly large percentage of the population. Tolerant species represent the 5-10% most tolerant taxa in a region. They are the opposite end of the spectrum from intolerant taxa.

Percent predator: Predators are the peak of the food web and depend on a reliable source of other invertebrates they prey on. The percentage of predator taxa provides a measure of the trophic complexity supported by a site.

Percent dominance (3 taxa): As diversity declines, a few taxa will begin to dominate the population. More tolerant or opportunistic species will replace sensitive or specialized species as habitat becomes more limited. This metric is calculated by adding the individuals in the three most common taxa and dividing by the total number of individuals in the sample.

Appendix B. Substrate Size Categories

Table B-1. Grain size ranges for substrate size categories used in visual observations and pebble counts.

Category	Grain Size Range
Sand	< 2 mm
Gravel	2-64 mm
Cobble	64-256 mm
Boulder	256-4096 mm
Bedrock	> 4096 mm

Appendix C. Compiled Habitat and Water Quality Data by EDT Reach.

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	Data Type	Data Originator	Notes
North Fork Lewis River	Cedar 2	B, H, WQ	CC vol	volunteer deployed datalogger and bug sample
North Fork Lewis River	Cedar 3	B, H, WQ	CC vol	volunteer deployed datalogger and bug sample
North Fork Lewis River	Cedar 6	B, H, WQ	CC/CC vol	volunteer deployed datalogger; two WQ stations
North Fork Lewis River	Chelatchie 2	B, H, WQ	CC	CC long term station located downstream; two WQ stations
North Fork Lewis River	John Creek	B, H	CC	alternate site added by consultant
East Fork Lewis River	Lockwood CreekB	B, H	CC	temperature data logger failure
East Fork Lewis River	LW Rock Creek	B, H, WQ	CC	CC long term station located upstream
East Fork Lewis River	McCormick CreekA	H, WQ	CPU	no bug sample; no pebble count
East Fork Lewis River	Rock Creek 4	B, H	CC	temperature data logger failure
East Fork Lewis River	Mason Creek	B, WQ	CPU	CPU bugs and habitat survey
East Fork Lewis River	Mill Creek	B, WQ	CC vol	no habitat survey; Pebble count only
East Fork Lewis River	EF Lewis 5	B, H	CPU	no temperature; bugs by CPU
East Fork Lewis River	EF Lewis 8A	B, H	CPU	no temperature; bugs by CPU
Salmon Creek	Rock 1	B, H, WQ	CC	
Salmon Creek	Salmon 32	B, H	CC	no temperature; alternate site added by consultant
Salmon Creek	Weaver 1	B, H, WQ	CC/CPU	two WQ station; temperature by CPU
Washougal River	Boulder Creek	B, H	CC	no temperature; alternate site added by consultant
Washougal River	Little Washougal 1	B, H, WQ	CC/CC vol	hydrology project temperature; volunteer bug sample
Washougal River	Little Washougal 1C	H, WQ	CC	
Washougal River	Little Washougal 2B	B, H, WQ	CC	
Washougal River	Washougal 3	H, WQ	CC vol	volunteer deployed datalogger
Washougal River	WF Washougal 1	H, WQ	CC vol	volunteer depolyed datalogger; not in ClarkCo
Washougal River	Little Washougal 2D	WQ	CC	
Washougal River	Washougal 4	WQ	CC vol	volunteer deployed datalogger

B = Macroinvertebrate Survey
H = Habitat Survey
WQ = Water Quality Survey
CC = Clark County Water Resources
CC vol = Clark County Volunteer
CPU = Clark Public Utilities

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	EDT Tier	ClarkCo SWS Group	Elevation (feet)	Ecoregion Level 4	ClarkCo WQ Station Codes
North Fork Lewis River	Cedar 2	3	I	190	Eco4a	CED050
North Fork Lewis River	Cedar 3	2	I	200	Eco4a	CED055
North Fork Lewis River	Cedar 6	3	I	295	Eco4a	CED070, CED080, CED085
North Fork Lewis River	Chelatchie 2	4	I	240	Eco4a	CHL030, CHL050
North Fork Lewis River	John Creek	4	I	375	Eco4a	JON010
East Fork Lewis River	Lockwood CreekB	2	J	30	Eco3d	LOC020
East Fork Lewis River	LW Rock Creek	2	I	275	Eco3d	RCN010
East Fork Lewis River	McCormick CreekA	2	M	30	Eco3a	MAC050
East Fork Lewis River	Rock Creek 4	1	B	900	Eco4a	RCS050
East Fork Lewis River	Mason Creek	4	J	30	Eco3d	MAS020
East Fork Lewis River	Mill Creek	2	N	80	Eco3a	MLN010
East Fork Lewis River	EF Lewis 5	1	E	20	Eco3a	EFL025
East Fork Lewis River	EF Lewis 8A	1	E	70	Eco3a	EFL030
Salmon Creek	Rock 1	3	I	355	Eco4a	ROC010
Salmon Creek	Salmon 32	3	I	440	Eco4a	SMN085
Salmon Creek	Weaver 1	4	M	230	Eco3a	WDN020, WDN030
Washougal River	Boulder Creek	3	H	680	Eco4a	BDR030
Washougal River	Little Washougal 1	2	B	100	Eco3d	LWG013, LWG015
Washougal River	Little Washougal 1C	3	B	295	Eco3d	LWG040
Washougal River	Little Washougal 2B	2	H	500	Eco4a	LWG050
Washougal River	Washougal 3	2	E	55	Eco3a	WAS020
Washougal River	WF Washougal 1	2	-	400	Eco4a	NWA010
Washougal River	Little Washougal 2D	2	B	500	Eco4a	LWG080
Washougal River	Washougal 4	2	C	90	Eco3d	WAS040

EDT = Ecosystem Diagnosis and Treatment
SWS = Subwatershed
Eco3a = Willamette Valley Portland/Vancouver Basin
Eco3d = Willamette Valley Foothills
Eco4a = Western Cascades Lowlands and Valleys

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	WQ Station Latitude	WQ Station Longitude	Max 7-DADValue (deg-F)	Max 7-DADDate (deg-F)	Days > 64
North Fork Lewis River	Cedar 2	45.9260194	-122.497595	74.0	8/12/2004	57
North Fork Lewis River	Cedar 3	45.9314468	-122.525631	74.0	8/12/2004	55
North Fork Lewis River	Cedar 6	45.9049841	-122.438963	67.1	7/25/2004	36
North Fork Lewis River	Chelatchie 2	45.9135513	-122.421294	62.7	7/26/2004	0
North Fork Lewis River	John Creek	45.9261446	-122.499656	-	-	-
East Fork Lewis River	Lockwood CreekB	45.8541431	-122.640826	-	-	-
East Fork Lewis River	LW Rock Creek	45.8385209	-122.522126	75.2	7/24/2004	67
East Fork Lewis River	McCormick CreekA	45.8517063	-122.691946	70.4	7/25/2004	70
East Fork Lewis River	Rock Creek 4	45.7750521	-122.337696	-	-	-
East Fork Lewis River	Mason Creek	45.8333976	-122.625240	71.2	7/25/2004	68
East Fork Lewis River	Mill Creek	45.8116587	-122.608235	61.4	7/25/2004	0
East Fork Lewis River	EF Lewis 5	45.8327971	-122.640385	-	-	-
East Fork Lewis River	EF Lewis 8A	45.8145173	-122.587549	-	-	-
Salmon Creek	Rock 1	45.7760372	-122.446284	72.2	7/24/2004	25
Salmon Creek	Salmon 32	45.7577396	-122.424483	-	-	-
Salmon Creek	Weaver 1	45.7579878	-122.536580	75.5	7/25/2004	78
Washougal River	Boulder Creek	45.6723351	-122.330519	-	-	-
Washougal River	Little Washougal 1	45.6090570	-122.352542	73.2	8/12/2004	54
Washougal River	Little Washougal 1C	45.6314255	-122.377683	69.7	8/12/2004	42
Washougal River	Little Washougal 2B	45.6512323	-122.349563	67.9	8/12/2004	37
Washougal River	Washougal 3	45.5860324	-122.354560	76.4	8/13/2004	59
Washougal River	WF Washougal 1	45.6127036	-122.219224	68.4	8/12/2004	39
Washougal River	Little Washougal 2D	45.6630341	-122.340717	65.9	8/12/2004	20
Washougal River	Washougal 4	45.6131466	-122.343556	74.6	7/26/2004	57

Max 7-DADValue = Maximum 7-Day moving average of the daily maximum water temperature
Max 7-DADDate = Date of the Max 7-DADValue
Days > 64 = Number of days the daily maximum value was greater than 64 deg-F

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	Bug Survey Date	BIBI Total Score	Total Taxa number	Ephemeroptera taxa number	Plecoptera taxa number	Trichoptera taxa number
North Fork Lewis River	Cedar 2	10/14/2004	32	35	6	4	6
North Fork Lewis River	Cedar 3	10/14/2004	34	44	8	7	5
North Fork Lewis River	Cedar 6	10/27/2004	48	42	9	8	11
North Fork Lewis River	Chelatchie 2	10/6/2004	26	39	6	7	9
North Fork Lewis River	John Creek	10/27/2004	44	43	8	9	12
East Fork Lewis River	Lockwood CreekB	10/12/2004	24	28	7	5	4
East Fork Lewis River	LW Rock Creek	7/28/2004	32	40	6	4	11
East Fork Lewis River	McCormick CreekA	-	-	-	-	-	-
East Fork Lewis River	Rock Creek 4	10/14/2004	42	44	9	8	7
East Fork Lewis River	Mason Creek	9/21/2004	32	33	11	4	5
East Fork Lewis River	Mill Creek	9/30/2004	28	30	3	8	6
East Fork Lewis River	EF Lewis 5	9/24/2004	28	33	6	5	6
East Fork Lewis River	EF Lewis 8A	9/24/2004	38	37	6	10	10
Salmon Creek	Rock 1	10/22/2004	26	36	7	3	7
Salmon Creek	Salmon 32	10/21/2004	38	44	7	7	10
Salmon Creek	Weaver 1	10/25/2004	22	29	3	0	4
Washougal River	Boulder Creek	10/11/2004	34	40	9	7	8
Washougal River	Little Washougal 1	10/3/2004	28	34	6	6	4
Washougal River	Little Washougal 1C	-	-	-	-	-	-
Washougal River	Little Washougal 2B	10/15/2004	42	38	10	8	7
Washougal River	Washougal 3	-	-	-	-	-	-
Washougal River	WF Washougal 1	-	-	-	-	-	-
Washougal River	Little Washougal 2D	-	-	-	-	-	-
Washougal River	Washougal 4	-	-	-	-	-	-

BIBI = Pacific Northwest Benthic Invertebrate Index of Biological Integrity

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	Long-lived taxa number	Intolerant taxa number	Tolerant taxa %	Predator taxa %	Clinger Taxa number	Dominance (three taxa) %
North Fork Lewis River	Cedar 2	5	0	42.9	12.1	24	54.3
North Fork Lewis River	Cedar 3	6	1	26.9	7.0	30	41.2
North Fork Lewis River	Cedar 6	7	4	7.0	19.9	25	40.6
North Fork Lewis River	Chelatchie 2	7	0	60.4	8.4	19	64.9
North Fork Lewis River	John Creek	8	4	19.5	16.1	26	39.8
East Fork Lewis River	Lockwood CreekB	7	0	53.3	7.8	14	61.3
East Fork Lewis River	LW Rock Creek	4	0	1.3	10.9	19	65.5
East Fork Lewis River	McCormick CreekA	-	-	-	-	-	-
East Fork Lewis River	Rock Creek 4	7	1	2.4	16.3	22	40.8
East Fork Lewis River	Mason Creek	6	0	7.6	6.8	17	71.8
East Fork Lewis River	Mill Creek	4	1	28.0	12.3	11	53.6
East Fork Lewis River	EF Lewis 5	5	0	34.3	7.0	11	74.0
East Fork Lewis River	EF Lewis 8A	10	2	23.3	13.7	23	22.0
Salmon Creek	Rock 1	8	1	34.3	5.2	19	55.0
Salmon Creek	Salmon 32	9	2	17.1	9.1	28	42.1
Salmon Creek	Weaver 1	5	0	23.5	3.9	12	74.6
Washougal River	Boulder Creek	6	2	15.9	9.6	20	49.7
Washougal River	Little Washougal 1	5	0	14.2	6.8	16	51.6
Washougal River	Little Washougal 1C	-	-	-	-	-	-
Washougal River	Little Washougal 2B	5	6	7.5	11.4	20	37.9
Washougal River	Washougal 3	-	-	-	-	-	-
Washougal River	WF Washougal 1	-	-	-	-	-	-
Washougal River	Little Washougal 2D	-	-	-	-	-	-
Washougal River	Washougal 4	-	-	-	-	-	-

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	Wetted Width (feet)	Bankfull Width (feet)	Map Gradient %	Field Gradient %	Sand %	Gravel %
North Fork Lewis River	Cedar 2	15.3	17.8	0.5	1.5	11	34
North Fork Lewis River	Cedar 3	13.0	15.8	0.5	1.5	15	39
North Fork Lewis River	Cedar 6	9.2	10.9	1.5	2.0	32	48
North Fork Lewis River	Chelatchie 2	6.6	7.8	0.5	0.5	44	50
North Fork Lewis River	John Creek	4.4	4.9	4.0	5.5	48	17
East Fork Lewis River	Lockwood CreekB	5.5	7.1	0.7	-	18	73
East Fork Lewis River	LW Rock Creek	5.9	6.8	2.0	-	5	26
East Fork Lewis River	McCormick CreekA	0.9	2.7	0.5	-	35	63
East Fork Lewis River	Rock Creek 4	9.9	13.9	1.4	-	3	28
East Fork Lewis River	Mason Creek	2.9	4.1	-	2.5	17	66
East Fork Lewis River	Mill Creek	-	-	-	-	11	50
East Fork Lewis River	EF Lewis 5	20.3	36.1	0.3	-	7	70
East Fork Lewis River	EF Lewis 8A	29.5	47.0	0.4	-	6	48
Salmon Creek	Rock 1	2.0	7.1	1.0	1.0	29	54
Salmon Creek	Salmon 32	3.0	5.6	4.5	1.0	38	47
Salmon Creek	Weaver 1	3.4	3.6	1.0	1.0	33	49
Washougal River	Boulder Creek	6.9	8.1	3.0	2.0	10	20
Washougal River	Little Washougal 1	11.2	13.2	1.1	1.5	18	34
Washougal River	Little Washougal 1C	11.2	14.0	1.6	2.0	14	21
Washougal River	Little Washougal 2B	10.9	13.4	2.0	1.5	17	24
Washougal River	Washougal 3	36.0	-	0.3	0.3	0	42
Washougal River	WF Washougal 1	16.9	20.7	2.5	-	7	17
Washougal River	Little Washougal 2D	-	-	-	-	-	-
Washougal River	Washougal 4	-	-	-	-	-	-

Sand = < 2 mm
Gravel = 2 - 64 mm
Cobble = 64-256 mm
Boulder = 0.26-4.1 m
Bedrock = > 4.1 m

Appendix C; Table C-1
Compiled water temperature, benthic macroinvertebrate, and habitat data, Clark County Water Resources 2004.

Watershed Name	EDT Reach Name	Cobble %	Boulder %	Bedrock %	D50 mm	D90 mm	Embeddedness %
North Fork Lewis River	Cedar 2	38	18	0	-	-	28
North Fork Lewis River	Cedar 3	34	12	0	-	-	29
North Fork Lewis River	Cedar 6	10	10	0	17	71	42
North Fork Lewis River	Chelatchie 2	5	1	0	17	60	66
North Fork Lewis River	John Creek	20	14	1	48	180	56
East Fork Lewis River	Lockwood CreekB	10	0	0	27	77	50
East Fork Lewis River	LW Rock Creek	42	27	0	109	437	20
East Fork Lewis River	McCormick CreekA	2	0	0	-	-	50
East Fork Lewis River	Rock Creek 4	59	10	0	109	309	20
East Fork Lewis River	Mason Creek	16	1	0	40	157	-
East Fork Lewis River	Mill Creek	38	1	0	39	154	25
East Fork Lewis River	EF Lewis 5	22	0	0	27.3	77	20
East Fork Lewis River	EF Lewis 8A	36	10	0	54.3	218	20
Salmon Creek	Rock 1	5	5	6	-	-	31
Salmon Creek	Salmon 32	11	3	1	-	-	57
Salmon Creek	Weaver 1	16	1	2	-	-	51
Washougal River	Boulder Creek	39	29	1	80	209	24
Washougal River	Little Washougal 1	28	11	9	54	120	39
Washougal River	Little Washougal 1C	18	24	23	40	573	28
Washougal River	Little Washougal 2B	28	21	10	67	147	35
Washougal River	Washougal 3	38	15	4	-	-	10
Washougal River	WF Washougal 1	29	32	16	146	324	25
Washougal River	Little Washougal 2D	-	-	-	-	-	-
Washougal River	Washougal 4	-	-	-	-	-	-

Sand = < 2 mm
Gravel = 2 - 64 mm
Cobble = 64-256 mm
Boulder = 0.26-4.1 m
Bedrock = > 4.1 m